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A CONCEPT OF THE ETIOLOGY OF GASTRIC AND DUODENAL ULCER*

CALDWELL LECTURE, 1955

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I AM highly honored by this invitation to give the Caldwell Lecture for 1955 and regret that I did not have an opportunity to know this distinguished member of your Society. I take pleasure, however, in acknowledging my great indebtedness to radiology in my daily work as a general surgeon and also in my experimental studies.

The problem of the cause of gastric and duodenal ulcer is a part of the more general question of the resistance of the gastrointestinal tract to the digestive action of its own secretions. This was well stated in a thoughtful paper by Joseph Warren[15] almost seventy years ago.

"The question is: Why do organisms which manifest such power of digesting and assimilating the material they require leave quite intact those organs or tissues where these processes go on so actively? Why does the stomach digest various albuminous substances so readily and yet fail to attack its own walls containing substantially the same material? Why do the intestines with their much more varied power of digestive action remain undisturbed and uninjured by this activity? Why does the pancreas secrete at least three vigorous ferments and yet work on unaffected by each and all of them?"

John Hunter[10] interested himself in this problem and explained the resistance of the normal gastric wall to digestion on the basis of a vital principle in the following picturesque language.

"If it was possible for an animal to live in the stomach of another animal, supposing digestion not to be going on in that stomach, it would then live while digestion was going on. For that animal would not be in the least dissolved because the living principle in the animal would prevent or counteract the digestive quality of the stomach. If this was not the case then we might readily suppose that even though the animal life was not immediately affected by the digestive power, yet at last

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FIG. 1. Photograph showing absence of digestion of spleen implanted into a defect in the dog's stomach (from Dragstedt, L. R. *Ann. Surg.*, 1935, *102*, 563, reproduced by permission).

it might be destroyed by the external and extreme parts of the animal being digested, and so the animal be obliged to die like a person with mortification. But that a living animal will not be so dissolved is every day proved by worms, maggots, or flies living in the stomach of many animals. And if it was a power that could act upon a part that had the living principle, as well as an acid can, then the stomach itself would certainly be dissolved. If one could conceive a man to put his hand into the stomach of a lion and hold it there without hindering the digestive powers, the hand would not in the least be digested. If the hand of a dead man was put in at the same time, whether separated or not from the body, that hand would be digested while the other would not."

From the time of Hunter many men have speculated and worked in this field and the idea has steadily gained headway that ulcers of the stomach and duodenum are in some way due to the corrosive digestive action of the gastric content. The widely adopted term peptic ulcer is an expression of that view. In health the stomach is not digested away and so it seemed necessary to postulate a local decrease in the resistance of the mucous membrane as a result of thrombosis or embolism (Virchow and Hauser) or some similar factor to account for ulceration. However, in spite of much effort very little evidence has been secured in support of this view. Extensive ligation of the arteries to the stomach in dogs is well tolerated, and when the critical point is passed, acute necrosis of a part of the stomach results rather than ulceration. Similar observations have been made in man when interference with the blood supply to the stomach has occurred as a result of translocation of the stomach into the chest to re-establish continuity after removal of portions of the esophagus. Ulcers usually develop in relatively young and otherwise healthy individuals with no evidence of arteriosclerosis of the gastric blood vessels or general nutritive impairment. I am persuaded that most ulcers are not due to a local decrease in resistance

Fig. 2. Photograph showing extensive digestion of spleen implanted into a Pavlov pouch and exposed to pure gastric juice (from Dragstedt, L. R. *Ann. Surg.*, 1935, *102*, 563, reproduced by permission).

to digestion, although this factor may be of importance in a few cases. If it was the usual determining factor, local resection of ulcers should be a more successful operation than experience has shown it to be.

If we look at the other side of the equation, the evidence is more satisfactory and I should like to present for your consideration the concept that peptic ulcers are usually due to an abnormal increase in the corrosive and digestive properties of the gastric content as a result of hypersecretion of gastric juice. Furthermore, that duodenal ulcers are usually due to a hypersecretion of gastric juice of nervous origin and gastric ulcers are usually due to a hypersecretion of humoral or hormonal origin.

The corrosive properties of the gastric content are due chiefly to the pepsin hydrochloric acid of the gastric juice. The other material present, namely, swallowed food and saliva, regurgitated intestinal secretions, and mucus secreted by the gastric antrum, all serve to dilute and buffer the gastric juice and reduce its corrosive properties. When an excessive secretion of gastric juice occurs, the neutralizing effect of these protective substances will be gradually overcome until eventually the gastric content has approximately the same concentration of acid and pepsin as exists in pure gastric juice. I believe the key to the ulcer problem was provided with the discovery that the pure secretion of the fundus of the stomach has the capacity to digest all living tissue including the mucosa of the duodenum and stomach itself. Previous injury is not required, but if this is present, the damaged area succumbs more readily than the neighboring mucosa.

A few representative experiments illustrate this point.[2] Organs, such as the spleen and kidney, remain unaffected if transplanted into defects in the stomach of dogs where they are exposed to the usual gastric content (Fig. 1), but are promptly digested away if implanted into similar defects in Pavlov pouches where they are exposed to the pure undiluted fundus secretion (Fig. 2). Pure gastric juice from accessory stomach pouches in dogs promptly causes typical peptic ulcers if caused to drain into the jejunum, ileum, or colon (Fig. 3). The totally isolated stomach of dogs devoid of vagus innervation but with intact blood supply secretes very

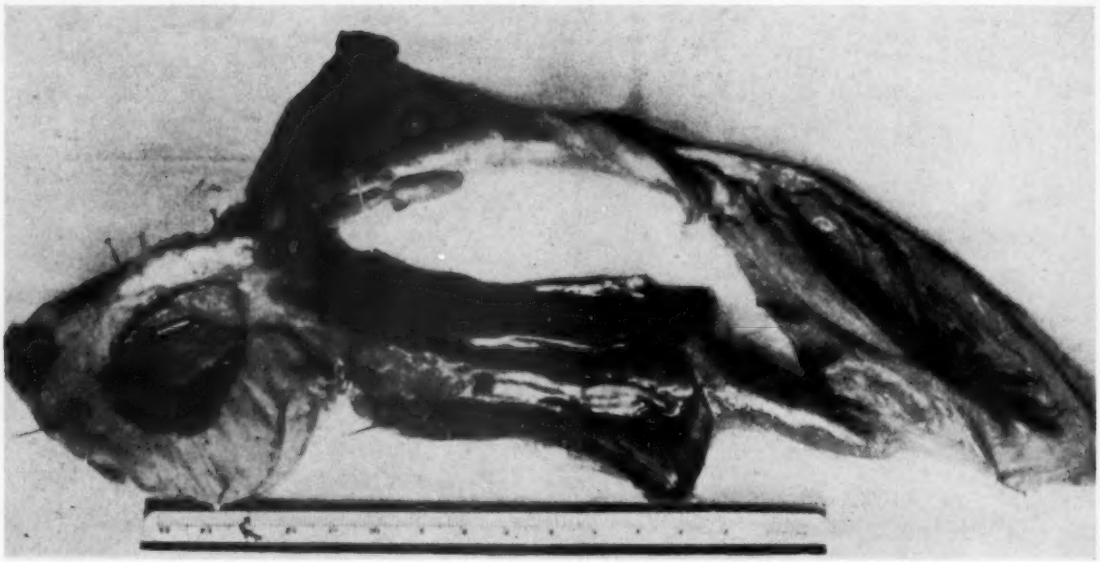

FIG. 3. Photograph showing typical peptic ulcer in the ileum caused by pure gastric juice from a Pavlov pouch diverted into the intestine (from Mathews, W. B. and Dragstedt, L. R. *Surg. Gynec. & Obst.*, reproduced by permission).

little gastric juice and usually remains free of ulcers. If the antrum from such an isolated stomach is transplanted into the colon, a marked hypersecretion of gastric juice occurs and typical gastric ulcers promptly appear in the isolated pouch (Fig. 4).

The evidence that duodenal ulcers are usually due to a hypersecretion of gastric juice of nervous origin may be listed as follows: If care is taken to make a nearly quantitative aspiration of the gastric content during a twelve hour period, free hydrochloric acid in the nocturnal secretion of duodenal ulcer patients is from three to twenty times as great as that secreted by normal people under the same conditions. In our experience normal adults put out between 15 and 20 mEq. of free hydrochloric acid in the nocturnal secretion when there is no food in the upper gastrointestinal tract and the patient is shielded from the sight, odor, or taste of food. Under similar conditions 1,000 duodenal ulcer patients on whom we have careful measurements secreted from 60 to 350 mEq. of acid. This fasting hypersecretion is undoubtedly significant because, if a hypersecretion of the same degree is reproduced in experimental animals, ulcers in the duodenum regularly develop. This demonstration was first made by Hay, Varco, Code, and Wangensteen[8] when they produced a sustained hypersecretion of gastric juice and typical peptic ulcers in dogs and other experimental animals by implanting pellets of histamine and beeswax into the subcutaneous tissues.

The disappearance of the hypersecretion in duodenal ulcer patients following complete division of the vagus nerves to the stomach indicates that it is of nervous origin.[3] These widely confirmed observations provide objective evidence in support of the concept that duodenal ulcer is a psychosomatic disease. It is interesting to speculate that in some way the tensions and strain a modern life produce a secretory hypertonus in the vagus nerves and that it is in this way the central nervous system plays a role in the disease. The persistence of this hypersecretion in duodenal ulcer patients during sleep and even after the administration of sedative drugs suggests that the hyperactivity has become established in some of the lower

Fig. 4. Photograph illustrating a large perforating ulcer which developed in a vagotomized total stomach pouch ten days after the antrum was removed from the pouch and transplanted into the side of the transverse colon (from Dragstedt, L. R., Overhelman, H. A., Jr., and Smith, C. A. *Ann. Surg.*, 1951, *134*, 332, reproduced by permission).

ganglia. If this is true, the possibility of affecting this hypersecretion by psychotherapy seems rather remote although the attempt ought to be made. It is interesting that division of one vagus nerve does not reduce the fasting secretion and that this may continue even if both main trunks of the vagus supply to the stomach have been divided and a relatively small branch has been left undisturbed. The fact that such a small vagus branch can activate the entire glandular mechanism of the stomach indicates that the connection between the vagus endings and the gastric glands is not simple and direct. It may be that the impulse is transmitted from the vagus nerves to the submucous plexus of Meissner and from the plexus to the glands. The intimate anatomical arrangement of nerve filaments from the plexus and the gland cells supports this possibility. At all events the necessity for division of all or nearly all of the vagus branches to the stomach is well established and there is no doubt that many failures in the surgical treatment of duodenal ulcer have been due to incomplete vagotomy.

The beneficial effect that complete gastric vagotomy exerts on the healing of duodenal ulcers constitutes the final and perhaps best evidence that these lesions are due to a hypersecretion of gastric juice of nervous origin. This fact has usually been lost sight of in the controversy as to

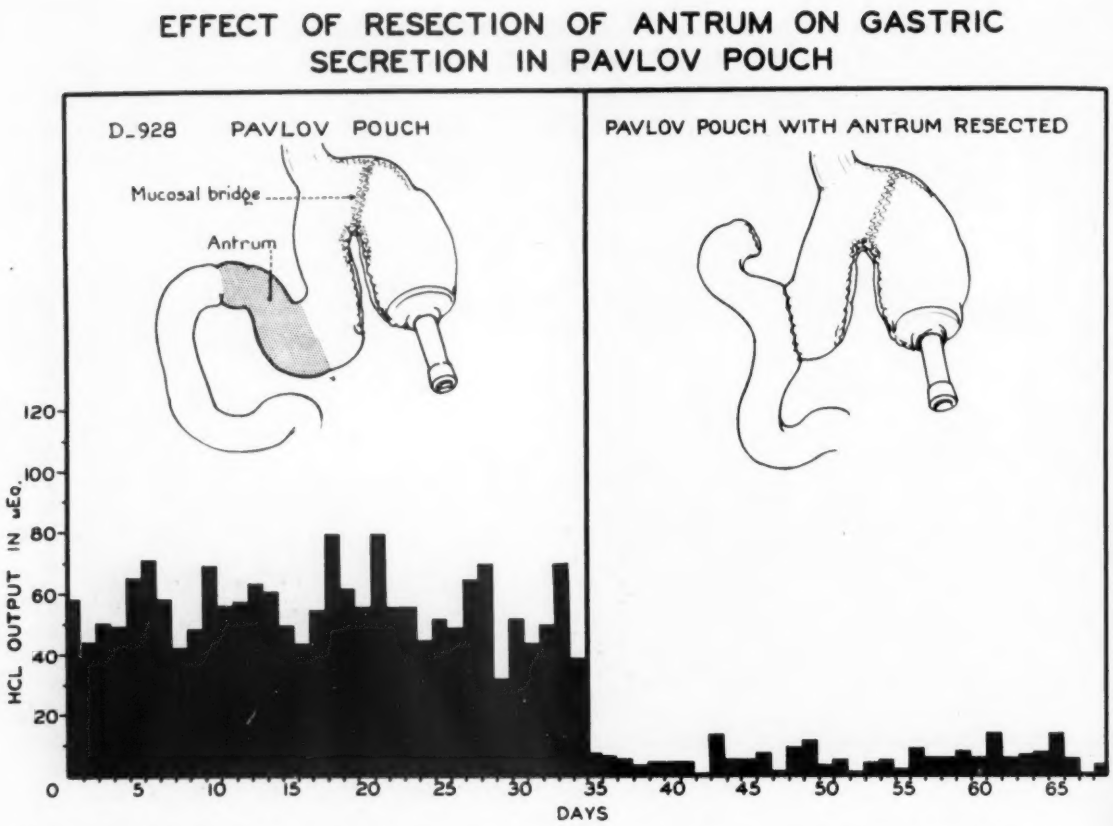

FIG. 5. Diagram showing the effect of resection of the antrum on the secretion of gastric juice from an accessory stomach pouch (from Dragstedt, L. R., Woodward, E. R., Storer, E. H., Oberhelman, H. A., and Smith, C. A. *Ann. Surg.*, 1950, *132*, 626, reproduced by permission).

whether vagotomy or subtotal gastric resection is the more effective operation. Many thousands of duodenal ulcer patients in all parts of the world have been cured of their disease by the vagotomy operation and in our own experience of over 1,100 cases, division of the vagus nerves to the stomach regularly abolishes the abnormal fasting hypersecretion, and if an adequate drainage operation has been done, the ulcers usually heal and remain healed. It is true that about 10 per cent of our patients have failed to get a good result, but if these cases are scrutinized, usually some reason for the failure is apparent. Most of them occurred in our early experience when the necessity for dividing all of the vagus nerves to the stomach was not fully appreciated and the fact that stasis of food in the antrum of the stomach could cause a prolonged hypersecretion of gastric juice of humoral origin was not known.

The concept that peptic ulcers are usually due to hypersecretion rather than to a local decrease in the resistance of the mucosa raised the question as to the possibility that this hypersecretion in some patients might be due to an exaggeration of the hormonal mechanism for stimulation rather than to the vagus nerves. Pavlov recognized that a secretion of gastric juice occurred on the ingestion of food even after the vagus nerves to the stomach had been divided, and accounted for this on the basis of local nervous reflexes. Edkins[6] postulated that this secretion arose as a result of stimulation of the gastric glands by a hormone which he designated as gastrin and which he stated was formed

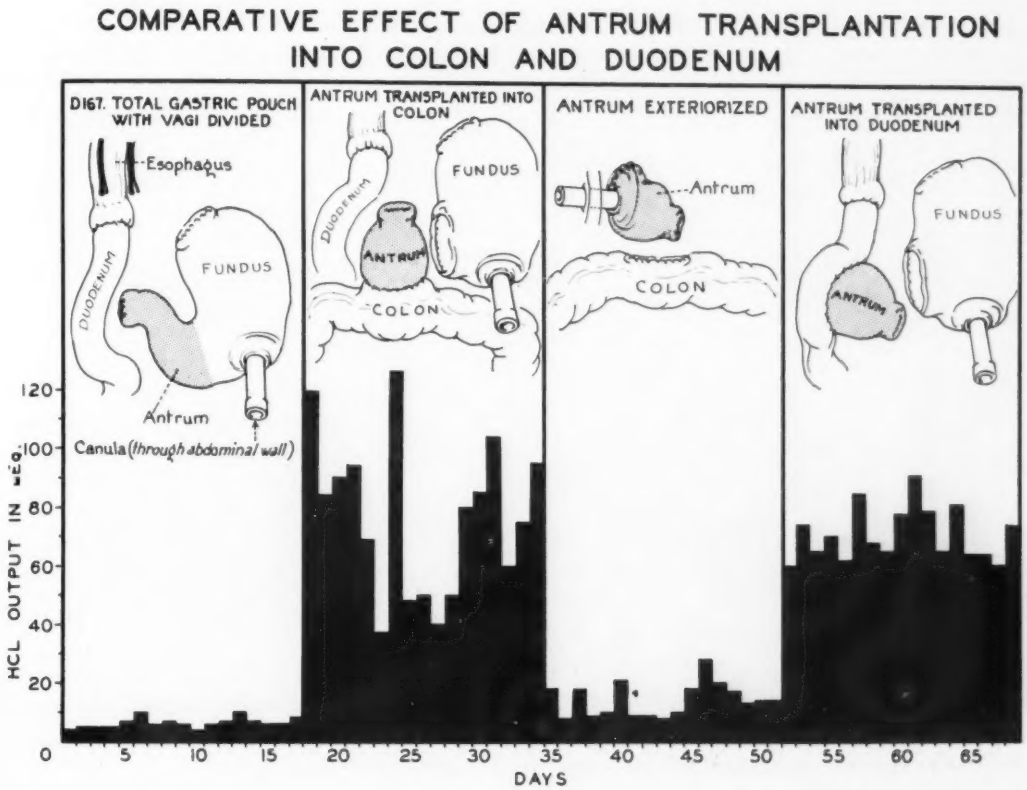

Fig. 6. Diagram showing the marked stimulation of gastric secretion when the antrum is transplanted into the colon, the fall in secretion when the antrum is transplanted into the abdominal wall, and the return when the antrum is transplanted into the duodenum (from *Ann. Surg.*, 1950, *132*, 626, reproduced by permission).

in the mucous membrane of the antrum of the stomach on contact with food or the primary products of digestion and, subsequently, liberated into the blood stream. This is one of the most remarkable guesses in the history of gastrointestinal physiology for it must be admitted, as Ivy[11] and Carlson[1] have pointed out, the experimental evidence provided by Edkins was scanty and inconclusive. It is likely that this gastrin theory was suggested by the previously discovered pancreatic secretin of Bayliss and Starling. My associates and I, however, became convinced of the validity of Edkins's theory when we[4] found that excision or transplantation of the antrum of the stomach to the abdominal wall markedly reduced the secretion of gastric juice from the vagus denervated stomach and that this secretion returned to its previous level when the transplanted antrum was again implanted into the duodenum (Fig. 5 and 6).

A further study of the physiology of the gastric antrum by the use of isolated antrum pouches[16] revealed that the application of food to the antrum mucosa would, indeed, stimulate the secretion of gastric juice by the fundus of the stomach as Edkins had postulated, but only if the food was neutral or at most faintly acid in reaction. The application of acid or acid food to the antrum mucosa immediately produced a cessation of this antrum hormonal function. This finding indicates that the normal stomach possesses in the antrum a mechanism both for initiating and for stopping the secretion of gastric juice. In the normal individual the fasting or continuous secretion is markedly augmented by the

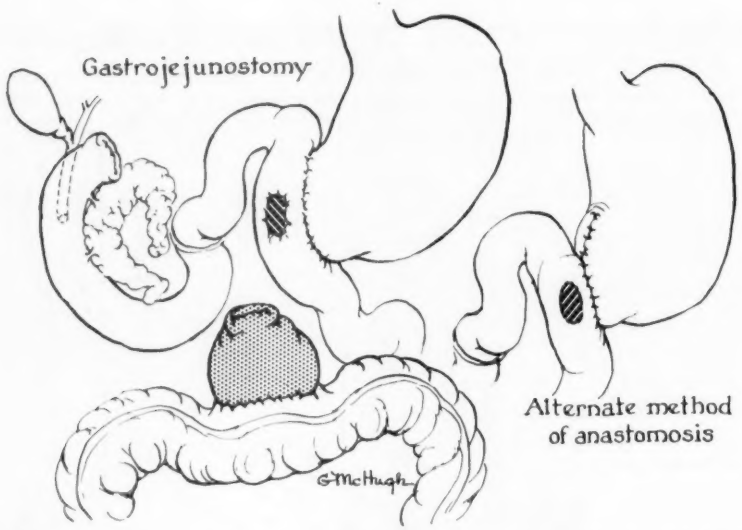

FIG. 7. Diagrams illustrating the method of producing gastrojejunal and gastroduodenal ulcers by transplantation of the antrum of the stomach into the transverse colon (from *Ann. Surg.*, 1951, *134*, 332, reproduced by permission).

sight, odor, or taste of food by means of conditioned and unconditioned reflexes mediated by the vagus nerves. Food promptly enters the stomach where gastric peristalsis is induced and the food is carried to the antrum where it comes in contact with the mucosa. Gastrin is then liberated and the humoral phase of stimulation provides for a secretion of gastric juice until the acidity of the gastric content approaches a pH of 2.5. At about this concentration of acid, further release of gastrin is inhibited and secretion stops presumably when sufficient gastric juice has been produced for the digestion of the meal.

Tension within the antrum, such as that produced by peristalsis, has been found to be quite as effective a method of stimulation of antrum function as is contact with food.[5] The previous application of solutions of procaine or of atropine sulfate to the antrum mucosa blocks completely the release of gastrin either by contact with food or the development of tension within the antrum. This must be due to some interference with the mechanism of gastrin release since the similar application of these solutions to the mucosa of the fundus causes no such inhibition. It is clear that the antrum of the stomach is an important endocrine organ and that much more work is required before the details of its function are clearly established.

One discovery that has proved fruitful is the finding that transplantation of the antrum of the stomach into the transverse colon as a diverticulum produces a sustained hypersecretion of gastric juice in dogs and typical peptic ulcer formation (Fig. 7 and 8). This indicates that ulceration due to a hypersecretion of gastric juice of humoral origin is more than a theoretical possibility although it must be admitted that a duplication of this experiment could occur, but rarely in human pathology. It seems probable that the hypersecretion of gastric juice induced by transplantation of the antrum into the colon is dependent partly on stimulation of the antrum by peristalsis and partly to the absence of acid inhibition of antrum function.

The experimental evidence available at the present time suggests that a hypersecretion of gastric juice of humoral origin in man could occur as a result of the hypermotility and hypertonicity of the stomach in the presence of pyloric stenosis or as a

Fig. 8 Photograph illustrating a stoma ulcer which appeared in the jejunum three weeks after implantation of the antrum into the colon (from *Ann. Surg.*, 1951, *134*, 332, reproduced by permission).

result of prolonged contact of food with the mucosa of the pyloric antrum brought about either as a result of mechnical obstruction or deficient gastric peristalsis. There is evidence that both of these factors are present in many gastric ulcer patients.

Although it had been previously noted that patients with long standing duodenal ulcers with pyloric stenosis and food retention are apt to develop secondary gastric ulcers, the studies of Huber and Huntington[9] are especially convincing. In beautiful roentgenograms these workers demonstrated the appearance of large gastric ulcers in patients where previous duodenal ulcers had caused pyloric stenosis with marked retention of food in the stomach. Pyloric stenosis should cause gastric hypermotility, increased tension within the antrum, and also prolonged contact of the antrum mucosa with stimulating chemicals in the food. We have recently secured evidence that these factors actually provoke a hypersecretion of gastric juice of humoral origin in some experimental studies conducted with my associates, Rigler, Oberhelman, Brasher, and Landor.[13] Experimental pyloric stenosis in dogs with vagus denervated Heidenhain pouches produced sustained hypersecretion from the pouch and in one case a typical gastric ulcer in the main stomach.

It is probable that not more than 20 per cent of gastric ulcers develop in patients with pyloric stenosis due to a previous duodenal ulcer. For the remainder, a hypersecretion of humoral origin must be dependent upon other factors than pyloric stenosis. It is in this connection that an experiment performed in our laboratory[7] and also independently by Storer and his associates[14] is of special interest. Heidenhain pouches devoid of vagus innervation were prepared in dogs and their secretory characteristics carefully measured during a controlled period. The

vagus nerves where then divided along the lower esophagus whereupon the output of gastric juice from the Heidenhain pouch was profoundly increased. This increase in the humoral mechanism of secretion was due to stasis of food in the stomach as a result of decreased gastric tonus and motility caused by the vagotomy since it did not occur if a previous gastroenterostomy had been made in the lower part of the stomach or if the antrum had been excised. It is thus evident that delayed gastric emptying of functional origin can cause a hypersecretion of gastric juice presumably as a result of prolonged contact of food with the antrum mucosa. Unfortunately, although all sorts of gastric examinations have been made on ulcer patients, we still do not have sufficient data on the frequency and extent of stasis in gastric ulcer patients independent of obstruction at the pylorus combined with continuing examinations of the concentration of acid and pepsin in the gastric content so long as food is present. Data of this type are clearly important both for the adequate care of the patient and for a further study of the disease. It is a pleasure to acknowledge the helpful cooperation of your president, Dr. Paul Hodges, in a study of this type which is presently being conducted in our hospital.

The idea that gastric ulcers are usually due to a hypersecretion of gastric juice of humoral origin is in harmony with many previous observations. Early in our work we found that gastric vagotomy was not so effective in the treatment of gastric ulcer as we had found it to be in duodenal ulcer patients. Furthermore, when vagotomy alone was done in the treatment of duodenal ulcer, stasis was not infrequent and 5 patients developed gastric ulcers as a secondary complication after periods of two to five years although the duodenal ulcers remained healed and the nocturnal gastric secretion was below the normal level. The subsequent employment of pyloroplasty or gastroenterostomy to prevent stasis of food in the antrum when vagotomy is done has very largely eliminated this complication.

Ihre[12] has called attention to the fact that, whereas duodenal ulcers occur usually in individuals subjected to unusual and prolonged stress and strain, this is not so evident in patients with gastric ulcers. Gastric ulcers were found to occur a decade later and were associated with irregular eating habits. In many series of duodenal ulcer patients, males predominate in a ratio of 5 or even 10 to 1, whereas in gastric ulcer the incidence of the two sexes is more nearly the same. It is, however, in the response to gastric surgery that the differences between gastric and duodenal ulcers appear most striking. In the early experience with gastroenterostomy, a high incidence of marginal ulceration was encountered when this operation was performed for duodenal ulcer, but rarely when done for gastric ulcer. These observations are in harmony with the view that gastric ulcers are usually due to a hypersecretion from stasis of food in the antrum and that this is corrected by the gastroenterostomy. In duodenal ulcer patients the hypersecretion is of nervous origin, persists after the gastroenterostomy, and causes a new ulcer in the less resistant jejunum. When gastric resection was first employed, only the lower part of the stomach, including the antrum and possibly a small portion of the body, was removed. When this low resection was performed for duodenal ulcer patients, marginal ulceration was not infrequent but rarely or never occurred when this operation was done for gastric ulcer. Here again it may be suggested that the low resection with removal of the antrum abolishes the cause of the hypersecretion in gastric ulcer patients and so they remain well. The nervous phase of secretion, however, persists after removal of the antrum and so a new ulcer forms. The concept that gastric ulcer is due to a hypersecretion of gastric juice due to antrum hyperfunction from stasis of food also explains the puzzling fact that excision of the antrum, as in the Kelling-Madlener operation, usually

causes the healing of a juxtaesophageal gastric ulcer which has been left *in situ*.

In this lecture dedicated to one of the great men in your science, I have tried to indicate the usefulness of physiological studies on lower animals in the solution of clinical problems. In many instances the ideas derived from these studies have been verified and supported by experience with patients. It is my hope that they may lead to more accurate and conservative surgical treatment. I should like, also, to support the claim of Pavlov that the method of surgery is a valid and useful technique for the solution of problems of a more fundamental scientific nature.

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THE DEVELOPMENT OF GASTROINTESTINAL ROENTGENOLOGY

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A MERE recording of the outstanding accomplishments in gastrointestinal roentgenology during the past fifty years would lead to the impression that this branch of medicine progressed in an orderly manner to its present high state. However, this is far from the truth for after the drama of the experimental work subsided, attempts at clinical correlation of roentgenologic findings usually produced nothing but frustration and many clinicians and surgeons said the method had no practical application. Fortunately, there was present, in both Europe and America, a small group of true medical scientists who devoted tremendous effort of this new approach to gastrointestinal diagnosis. In this country Cannon, Cole, Carman, Case and Hickey wrote their names indelibly in the early history of gastrointestinal roentgenology while in Europe Rumpel, Rieder, Haudek, Holzknecht, Haenisch, Schwarz and Groedel were outstanding investigators.

There are still among us men who played a vital role in the development of accurate gastrointestinal diagnosis and who vividly remember their associations with the early workers. For the younger group of roentgenologists and gastroenterologists who are so dependent on the principles laid down by these men and their fraternity, it is refreshing to review their accomplishments. As one reads of their trials and tribulations, a sense of indebtedness and humility prevails.

Following the discovery of the roentgen ray by Wilhelm Conrad Röntgen in November, 1895, the scientific world was soon informed and on December 9, 1896, W. B. Cannon, a medical student at Harvard, began studying the act of deglutition in animals with fluoroscopic observations of swallowed bismuth subnitrate. He first watched pearl buttons pass down the esophagus of a dog and subsequently observed the swallowing act in chickens, geese and other animals. These studies were done with capsules of bismuth subnitrate but in 1897, the bismuth was mixed with food and the movements of the esophagus and stomach were studied in the cat. Possibly simultaneously or shortly after Cannon's experiments, Roux and Balthazard of France used bismuth and water in roentgenologic studies of the esophagus and stomach in frogs, dogs and humans but their studies were not as detailed as Cannon's. In the early part of 1897, Rumpel of Germany visualized the esophagus in a patient who had dysphagia. Dilatation and obstruction were demonstrated by the use of 300 cc. of a 5 per cent suspension of bismuth subnitrate.

Both in Europe and the United States interest rapidly mounted in this new method of studying the physiology of the gastrointestinal tract and in September, 1899, Francis H. Williams of Boston, with the help of Cannon, examined the gastrointestinal tract of three children. Bismuth was mixed with bread and milk and the progress of this opaque material was followed by roentgenoscopic observation until the distal colon was reached. In 1901, Williams published his book, *The Roentgen Rays in Medicine and Surgery*, and a short quotation gives his forecast of the future of gastrointestinal roentgenology, "Thus we see that if bismuth is given, an outline of the stomach, its position in inspiration and expiration and some peculiarities of shape may be noted; likewise changes in rapidity with which digestion proceeds in different individuals may be watched. After various characteristics belonging to the stomach in health have been established, the presence of abnormal conditions of this organ, such

as some cases of malignant disease, will perhaps be more readily recognized than at present. The constant presence of a darkened area in the stomach, for example, may suggest the thickening of its walls due to malignant disease; some displacements or adhesions may be recognized as well as hour glass contractions, or an unusual delay of the digestive process."

One of the major advances in the roentgen visualization of the stomach was made by Rieder of Germany in 1904. He used large amounts of bismuth subnitrate mixed as a thick paste and was able to obtain roentgenograms of the entire stomach and small bowel. Previous to this work the bismuth was mixed with food and complete delineation of the stomach was not possible. With Rieder's opaque meal roentgenologists were well able to visualize the gastrointestinal tract but because of the long exposures (10–30 minutes) required to produce a roentgenogram, the early observers relied on the fluoroscopic examination. About this time one of the outstanding surgeons, W. J. Mayo, repeatedly emphasized that the stomach was the "sounding board of the abdomen." He of course meant that many intra-abdominal lesions gave rise to symptoms such as nausea, vomiting and epigastric pain which might lead one to suspect the stomach when actually some other organ was involved. Because of this statement, roentgenologists attempted to correlate "abnormal motility" of the small bowel, opacification of the appendix, and "incompetence of the ileocecal valve" with various motor phenomena of the stomach and with symptoms referred to by Mayo.

During this period of indirect diagnosis, Holzknecht, Groedel and others in Germany emphasized the need for palpation of the opacified areas under fluoroscopic control and Holzknecht developed a wooden device which enabled him to exert pressure on the abdomen without actually placing his hand in the irradiated field. Improvements in equipment enabled Lewis Gregory Cole of Cornell to produce excellent roentgenograms of the gastrointestinal tract and he developed a routine, calling for as high as sixty roentgenograms for each patient. Rieder, Schele and Haenish were not satisfied with the visualization of the colon obtained by the bismuth meal and obtained marked improvement by retrograde filling under fluoroscopic control.

1906–1920

Many of the early investigators did not rely entirely on the deformity of outline of the opacified viscus. Holzknecht and Braun (1906) visualized the gastric rugae by using a thin aqueous mixture of bismuth and then obtained a double contrast effect by having the patient swallow a mixture of tartaric acid and sodium bicarbonate. The carbon dioxide liberated in the stomach was radiolucent while the bismuth was radiopaque. In 1909, Cole used a thin aqueous suspension of bismuth, in preference to the thick Rieder meal, when he wished to study the mucosal folds of the stomach. The roentgenograms he produced with his mucosal technique compare favorably with those of today. Other workers found that by filling the stomach with a very thin mixture of bismuth and water, tumors could be "seen" through this medium while it was still possible to detect deformity in outline.

From Cannon's original research up to about 1910, most of the work was characterized by efforts to better visualize the intestinal tract, establish normal findings and attempt to interpret the abnormal in the light of operative or postmortem findings. The path was far from easy and Barclay (England) said of his early experiences, "The opinions I gave as the result of the x-ray examination were as often wrong as right and in many of the failures of diagnosis it seemed that I was hopelessly beside the mark; so much so that at times I had little confidence in the work and little hope of ever becoming successful." Others had this same experience and began to look for direct evidence of dis-

ease processes rather than relying on the indirect signs. The period from 1910 to 1915 was probably the most fruitful of any in the development of gastrointestinal roentgenology. The term "duodenal cap" so commonly used today originated with Lewis Gregory Cole's observation that this portion of the duodenum sat like a stocking cap on the pyloric end of the stomach and he applied the name "pilleus ventriculi" or cap of the stomach. By his multiple plate technique, Cole soon learned that when there was a constant defect in outline of the cap a duodenal ulcer would invariably be found during surgical exploration. He observed, "While there are many normal variations in the size, shape and position of the cap, a persistent deformity of outline is an accurate sign of the presence of a duodenal ulcer."

Haudek (Germany) was the first to describe the roentgen visualization of a gastric ulcer crater. His report in 1910 described the ulcer niche and the pocket an ulcer would form when it penetrated into a contiguous organ. In 1911, Pfahler in this country and Holzknecht in Germany described the deformity of the bismuth shadow in instances of gastric carcinoma. Leonard (1913), who himself was later to become a victim of overexposure of his hands, warned, "The palpation of the abdomen with the hand of the observer during fluoroscopic examination is dangerous and cannot be too strongly censored."

In spite of Leonard's warning, Carman found that his fluoroscopic observations were greatly enhanced by direct palpation of the abdomen. He recommended the use of a leaded protective apron and gloves and developed his fluoroscopic technique to the point where it would take an average of five minutes to adequately examine the stomach and duodenum. He did not rely on the reports of others to confirm his diagnosis or point out his mistakes but routinely followed his patients to the operating room to directly observe the surgical findings. By 1914, he was able to report that thirty-nine of forty-seven patients operated on for gastric ulcer were diagnosed as such by preoperative roentgen findings of a gastric ulcer crater. Carman's experience was so great that, working with W. J. Mayo and C. H. Mayo, he concluded in this same 1914 report, "The roentgen diagnosis of gastric ulcer is important for the microscopic examination often shows carcinomatous cells and therefore the diagnosis of ulcer is often equivalent to the diagnosis of early cancer when surgery can be the first instead of the last resort." Some years later, Carman himself died of cancer of the stomach after making the diagnosis on his own plates.

In 1914, George and Gerber confirmed Cole's findings in the direct diagnosis of duodenal ulcer and dismissed the secondary signs as having little importance. In this same year all three of these authors reported that the findings of a normal roentgen outline of the stomach and duodenum accurately ruled out the presence of an organic lesion.

Also in 1914, a great impetus was given to the field of gastrointestinal roentgenology by W. D. Coolidge's development the year before of a greatly improved roentgen tube. Not only was the fluoroscopic image intensified by this invention but roentgenographic exposures were greatly shortened so that motion of the patient or intestinal tract was no longer a serious deterrent.

During this period of active development of gastrointestinal roentgenology, much discussion ensued regarding the merits of the Cole versus Carman technique. While Carman did emphasize the fluoroscopic part of the gastrointestinal examination he, nevertheless, said that both fluoroscopy and roentgenography should be considered as indispensable complements to each other in every complete examination.

In spite of various techniques, Cole, Carman, Case, Holding and others arrived at the same conclusions, namely, that for utmost accuracy the roentgenologic examination had to depict the actual disease

process. In emphasizing this fact, Holding described the deformity of the duodenal cap when involved by ulcer and the deformity of the stomach in instances of ulcer and cancer in much the same manner we do today. He, like Carman, was unable to differentiate between a benign and malignant gastric ulcer.

Although most effort was devoted to the development of the stomach examination, George and Pfahler found they could visualize up to 50 per cent of all gallstones in the living patient but in 1915, Cole was able to show that about 80 per cent of all gallstones were nonopaque to the roentgen ray, and in spite of good quality roentgenograms little could be expected from the roentgen examination of the gallbladder.

The five-year period, (1910–1915), did not produce comparable brilliant results as far as the colon examination is concerned. Stierlin in 1911, first pointed out the absence of the barium shadow in tuberculosis of the cecum and ascending colon but neither Schilling, Schwarz or Groedel in Germany, nor Cole, Carman or Case in this country could differentiate with any degree of certainty between a benign or malignant process in the colon. Most observations consisted of obstruction, filling defect, stenosis or a palpable mass as indicative of an organic lesion.

In 1917, Carman published his book, *The Roentgen Diagnosis of Diseases of the Alimentary Canal.* He gathered the widely scattered but authenticated reports concerning gastrointestinal roentgenology and added his own observations. The revised second edition published in 1920 reveals that the roentgenologic examination of the esophagus had progressed to the point where cardiospasm, carcinoma, stenoses and diverticula were readily recognized, but Carman cautioned that the roentgenologic appearance of benign stricture was not characteristic.

Carman's experience with gastric carcinoma showed that 95 per cent of all cases showed roentgenologic evidence of the disease and he recognized the roentgenologic appearance of the polypoid as well as the scirrhous type. Neither Carman nor his contemporaries could differentiate a benign from a malignant gastric tumor but multiple gastric polyps were easily recognized. As has been shown the roentgenologic detection of gastric and duodenal ulcer was fully developed by this time and the pioneers reported the roentgenologic findings in cases of eventration of the diaphragm, diaphragmatic hernia and trichobezoar. Infantile pyloric stenosis was of course a clinical entity, but considerable doubt existed concerning the value of the roentgen examination. Carman had no experience with this disease but suggested the possibility of repeated examinations after the use of antispasmotics. While the early investigators were attempting to attach significance to indirect signs of gastrointestinal lesions, many of them believed that the roentgenologic findings of visceroptosis could be correlated with various clinical symptoms. Carman recognized the fallacy of this deduction for he observed this positional change in many patients who had no symptoms or disease of their gastrointestinal tract.

The small bowel yielded few of its secrets to the men of this period and Carman noted that, aside from observation of motility, the only roentgenologic finding of value was dilatation of the bowel above an area of obstruction. The exception to this simplification is the recognition of narrowing and spasm in the terminal ileum, as reported by Brown and Sampson, in instances of involvement by tuberculosis.

The summation of evidence for the diagnosis of carcinoma of the colon showed that the most reliable signs were obstruction to the retrograde flow of the opaque medium, narrowing of the lumen of the bowel or a persistent unilateral filling defect. Carman and Case found that, when persistent narrowing of the bowel was associated with diverticula, the surgical findings usually showed diverticulitis, while persistent narrowing in the cecum or ascending colon often indicated the presence

of tuberculosis. One of Carman's outstanding achievements as far as the colon examination is concerned was his critical observation that the so-called mucous and catarrhal colitis showed no abnormal roentgenologic findings while the true chronic ulcerative colitis invariably showed evidence of its presence when the involvement was above the rectum. The lack of haustration, shortening of length, absence of flexures, stenoses and granularity of the mucosa were all detected by this astute observer.

In this amazing period of gastrointestinal diagnosis, polyposis and megacolon were correctly diagnosed by several roentgenologists and Carman proved to his own satisfaction that the so-called incompetence of the ileocecal valve to the retrograde flow of the barium suspension was of no diagnostic or clinical significance.

The State of Michigan furnished two outstanding pioneers in the development of gastrointestinal roentgenology. Preston M. Hickey of Detroit and James Case of Battle Creek were among the pioneers who developed the basic principles of gastrointestinal roentgenology. Case was able to correlate his observations in a large number of patients who had gastrointestinal disease or dysfunction, while Hickey, who had a splendid background in pathology, emphasized the need of interpretation of abnormal roentgen findings on the basis of the gross pathologic changes characterized by each disease process. Hickey established one of the fundamental principles of gastrointestinal roentgenology when he wrote, "In cases where the x-ray examination is the principal factor in deciding for or against an operative procedure, it is highly advisable to have a second confirmatory examination before pronouncing the final diagnosis."

1920–1930

Many roentgenologists benefited from the experience of the pioneers, and gastrointestinal roentgenology became a well established branch of medicine beginning about 1920. Advances were characterized by Carman's description of the meniscus sign in 1921, Fischer's work with the double contrast examination of the colon and Graham and Cole's epochal work on opacification of the gallbladder. The pioneers were troubled with their inability to distinguish a benign from a malignant gastric ulcer but Carman showed that in some instances of gastric ulceration, malignancy was indicated when the ulcer crater did not project out from the gastric outline, was surrounded by a halo of piled up tumor tissue, the crater itself was irregular in outline and the gastric rugae were not radiating towards the crater. In 1923 and again in 1925 Fischer of Germany reported in detail on his method for accomplishing the double contrast examination of the colon. He described his experiments with surgically resected lengths of human colon and found that by employing a suspension of barium sulphate, hydrated aluminum silicate and water he could obtain excellent double contrast roentgenograms, provided that only a small amount of the suspension was used and the specimen vigorously shaken to distribute the opaque medium and then, following this, the specimen was distended by air injection. Fischer applied this procedure to patients. In some instances he would immediately follow the opaque medium with air injection and in others he would first permit partial evacuation of the enema. Multiple roentgenograms with the patient in various positions permitted Fischer to visualize intraluminal tumors which might be obscured by a solid column of barium.

Sehrwald of Germany in 1896, showed the halogens to be opaque to reontgen rays and predicted that internal organs might be filled with these chemicals and thus cast a shadow on the roentgenogram. In 1909 Abel and Rowntree found that a halogen addition to phenolphthalein, resulted in a preparation which could be injected intravenously and was soon excreted by the liver along with bile. In 1924, Graham and Cole of St. Louis developed sodium tetra-

iodophenolphthalein, which likewise could be injected intravenously in human beings without producing toxic effects and they reported clear cut roentgen opacification of the gallbladder. Roentgenologists throughout the world promptly put this new examination on trial and in a short time it was found that the chemical could be administered orally with equally good results. Hundreds of reports concerning experiences with the new gallbladder examination soon appeared. Kirklin had excellent opportunities to give this examination a thorough clinical trial. He correlated the roentgenologic and pathologic findings, emphasized the importance of a rigid routine of preparation of the patient, dosage of the media, proper sequence of roentgenographic exposures and good roentgenologic technique. He, as well as others, were soon able to conclude that this new examination was about as accurate as any test in the field of medicine.

1930–1940

The years of 1930–1940 again represent an important period in the development of the roentgenologic examination of the gastrointestinal tract. In the beginning of this decade, Weber modified and improved Fischer's double contrast examination of the colon and was soon consistently able to produce roentgenograms which could reveal the presence of small intraluminal tumors. While the pioneers had a great deal of difficulty differentiating between a benign and malignant process in the colon, Weber correlated their work with his own observations and then developed criteria which have proved to be most adequate for the diagnosis of carcinoma of the colon. These findings so accurately predicted the presence of a malignancy that, by their mere absence, Weber was readily able to recognize a non-malignant tumefactive process. Many roentgenologists have noted that Weber's criteria for the diagnosis of carcinoma of the colon apply equally well in the esophagus and small bowel.

During this same period, Bargen, Buie and Weber studied their cases of chronic ulcerative colitis in great detail and were able to present a clear clinical, proctoscopic and roentgenologic picture of this hither-to confusing disease process. Following Brown and Sampson's recognition of tuberculosis of the small bowel, little was accomplished until 1932, when Crohn, Ginzburg and Oppenheimer reported their findings of a small bowel inflammatory process somewhat similar to tuberculosis but without a recognizable causative organism. At first this process was thought to be limited to the distal portion of the small bowel and the term terminal ileitis was applied. Further observations showed that other portions of the small bowel could be involved by the same process and the accepted terminology became regional enteritis.

The accuracy of cholecystography was further improved in 1933, with Kirklin's findings that he could diagnose the presence of one or more papillomas or an adenoma of the gallbladder. The year 1936 saw the development of the Miller-Abbott tube for the decompression of the small bowel in instances of obstruction but roentgenologists used the procedure of small bowel intubation to more accurately localize obstructions and in some instances injected opaque media via the tube in an effort to determine the nature of the obstructing lesion.

1940–1956

From 1940 to the present time, the roentgenologic examination of the gastrointestinal tract has assumed a vital role in modern medicine. The progress during this period may best be reviewed by considering each major division of the tract:

1. *Esophagus.* The technique of the examination has changed only slightly since Carman's time. The diagnostic yield has been increased by observation of extrinsic pressure defects caused by various congenital cardiovascular diseases. Schatzki and Hawes (1942) presented the roentgen

characteristics of submucosal tumors of the esophagus and the demonstration of sizable varices is now common, but practically no roentgenologic progress has been made towards the earlier diagnosis of carcinoma of this organ. Interesting, but not diagnostic, observations have been made in instances of myasthenia gravis and scleroderma and while the roentgenologist now understands more of the role of the myenteric plexus he is still limited in the diagnosis of functional disorders.

2. *Stomach.* Harrington's monograph (1940) on the etiology, classification and surgical treatment of diaphragmatic hernia has spurred roentgenologists to make diligent efforts for the detection of this abnormality. While the pioneers found roentgenologic evidence of this type of hernia, Harrington's work has led to a better understanding of the anatomic and physiologic findings. In some instances of reflux of acid gastric contents into the esophagus, roentgenologists now can recognize peptic ulceration and other signs of esophagitis.

During the past 15 years, several worth while studies have been presented on the accuracy of the roentgenologic diagnosis of gastric ulcer. It is now generally agreed that from 10–20 per cent of all gastric ulcers showing no roentgenologic evidence of malignancy actually are malignant when first seen. The introduction of the flexible gastroscope by Schindler created a renewed interest in the roentgenologic examination of the gastric mucosa but this search has not revealed any characteristic roentgen findings. Perhaps this last fifteen-year period is most outstanding for, in spite of technical improvements and thorough fluoroscopic and roentgenographic procedures, the roentgenologist has become acutely aware of his inability to accurately differentiate benign from malignant lesions.

3. *Gallbladder.* Several new media have been developed with each showing improvement over tetraiodophenolphthalein and it is now possible to consistently visualize the common bile duct by intravenous injection of a new opacifying agent. All of these compounds depend upon their iodine content to produce roentgen opacity. A new disease entity, emphysematous cholecystitis, has been adequately described and, although the condition is not common, the roentgenologic findings are characteristic.

4. *Pancreas.* The roentgenologic diagnosis of diseases of the pancreas has been limited to the detection of calculi and displacement of contiguous structures by tumors of this gland. Detailed studies of pressure defects in the mucosa of the descending duodenum have led to the discovery of tumefaction of the head of the pancreas and enlargement of the ampulla of Vater.

5. *Small Bowel.* Beginning with Snell and Camp's observations of the changes in motility and mucosal pattern in cases of chronic idiopathic steatorrhea, many investigators noted alterations in motility and structure of the small bowel in deficiency states (blood proteins, vitamins, etc.) and in some patients with definite gastrointestinal manifestations of an allergic reaction. These roentgenologic findings are useful to the clinician but are not diagnostic and are merely secondary signs.

The diagnosis of primary malignancy of the small bowel still rests on the ability of the observer to elicit the same changes which occur in carcinoma of the colon and the last fifteen years have seen no marked advance in the diagnosis of inflammatory processes. The roentgenologic examination of the small bowel is still a difficult procedure; the diagnostic yield is low and the accuracy is less than elsewhere in the gastrointestinal tract.

6. *Colon.* The role of the myenteric plexus in disease of the gastrointestinal tract has been emphasized by Swenson, Neuhauser and Pickett with their new concept of the diagnosis of and treatment of megacolon. They have shown that the

dilated portion of the colon is essentially normal but that the colon distal to the dilated segment does not contain the myenteric plexus. The roentgenologic examination shows an area of narrowing corresponding to this defective segment and surgical removal with insertion of the normal but dilated sigmoid into the anal sphincter results in cure of this physiologic obstruction.

Progress of the colon examination has been characterized by more intensive efforts to demonstrate small polypoid lesions. Many authorities have warned of the significance of these tumors and considerable progress has been made in the efficiency of the double contrast examination. Roentgenologists have found that, with complete cooperation of the clinician and proctologist, the colon examination can detect early carcinoma while this seldom can be accomplished elsewhere in the gastrointestinal tract.

* * *

Certainly this historical review points out that much has been achieved in the roentgenologic diagnosis of gastrointestinal disease but the limitations of the examination must be recognized and emphasized. The future will see further progress in diagnostic yield but at present the examination can be improved if the roentgenologist has complete cooperation of the referring physician before the examination is begun and, equally important, if the roentgenologist will convey the full significance of his report to the physician.

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LATERAL PHARYNGEAL DIVERTICULA*

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LATERAL pharyngeal diverticula are unusual defects of the hypopharynx that may escape detection because of their location and rarity. They should be considered in the differential diagnosis of dysphagia, especially when the symptoms are of long duration and the cause obscure. The following case illustrates these points

REPORT OF CASE

The patient, a seventy-five year old white male, complained of difficulty of swallowing. As far back as he could remember, he had had episodic dysphagia lasting from two to three weeks at a time. The sensation was that of a sore throat and food sticking high in his neck. Often he would regurgitate the masticated but undigested food several hours later. His present episode had lasted three weeks.

The patient developed pulmonary tuberculosis about twenty years ago and has been hospitalized intermittently since. About five years previous to his present admission a carcinoma of the lip had been excised.

Examination of his neck revealed that there were no palpable masses and no dimpling of the skin.

A barium study of the pharynx and esophagus revealed a small pouch arising high on the right lateral wall of the pharynx at a level of the vallecula. It was connected to the pharynx by a narrow aperture and it measured about 4 centimeters at its greatest diameter. The pouch was filled easily (Fig. 1 and 2) and could be emptied to some extent by changes in position. For several minutes following ingestion, barium was retained in the vallecula and for four hours barium could be demonstrated in the diverticulum (Fig. 3). A moderately sized hiatus hernia was also observed.

Following the roentgenologic study the patient had a careful endoscopic examination of the hypopharynx. A small slit-like groove was found in the right vallecular wall. With some difficulty this opening could be probed and a portion of the pocket beyond visualized.

DISCUSSION

The classification of the pharyngeal diverticula is not entirely clear. Zenker's diverticulum, the posterior pulsion type, is relatively common and is well documented.[10] Concerning the rarer types of pharyngeal diverticula, less is known and the descriptive material is scarce. They have been described as occurring laterally, posteriorly, and anteriorly.[13]

TABLE I

PHARYNGEAL DIVERTICULA

I. Posterior	
	Acquired
	Zenker, Killian, and Laimer
	Congenital
	Brintnall and Kridelbaugh
II. Lateral	
	Acquired
	pharyngocele, artificial
	Congenital
III. Anterior	

Lateral Diverticula. These are for the most part congenital in origin. They are thought to be remnants of the third or fourth branchial clefts which are normally obliterated during the course of development. At about the sixth week of gestation the cervical sinus, which is formed from the branchial clefts, is found extending from the tonsillar fossa to the skin of the neck.[1] Failure of closure of the sinus may lead to anomalous fistulas, pouches, or cysts any-

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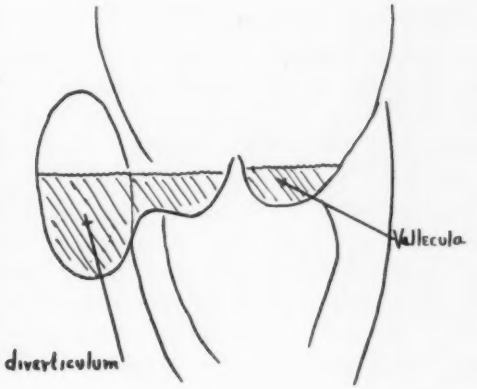

Fig. 1, *A* and *B*. Anteroposterior view showing barium and air distending the diverticulum. Its origin from the vallecula of the hypopharynx is readily seen.

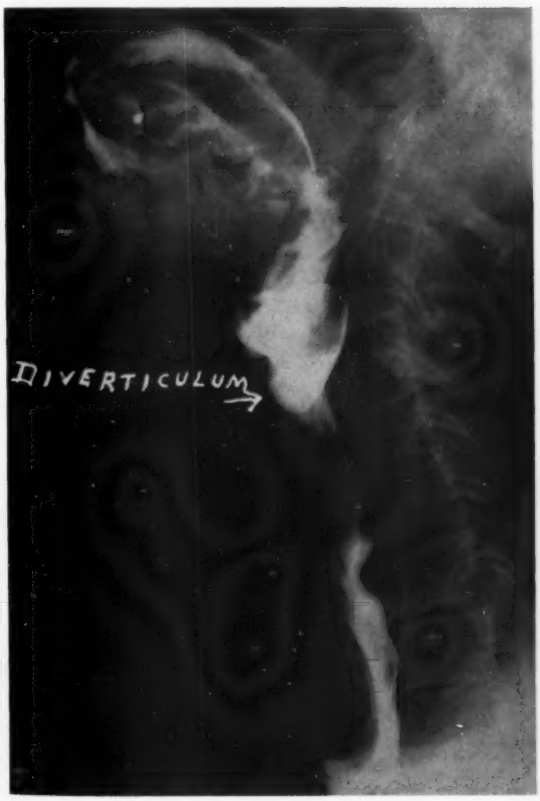

Fig. 2. Lateral view of the pharynx showing the barium filled pouch.

Fig. 3. Film taken several hours following barium ingestion, showing the sac in the right side of the neck.

where along its course. The manifestations vary from a simple dimpling of the skin or pharyngeal mucosa to the formation of a complete tract. A lateral pharyngeal diverticulum is presumably an open pharyngeal tract with a blind ending.[7] Raven,[12] in a complete survey of the embryologic and morphologic aspects of these pouches, notes the work of Frazer who studied the role of the hypoglossal nerve in the formation of blind cervical pouches. The nerve, early in the course of development, lies posterior to the branchial arches and grooves, but ultimately it lies anterior to the pharyngeal structures. Thus, it is thought that any connection persisting between the surface and the pharyngeal wall or its derivatives would be caught up by the nerve and obliterated. It is not surprising, therefore, that complete cervicopharyngeal fistulas are rare. Raven further classifies congenital lateral diverticula into three types, depending on whether they are derived from the second, third, or fourth embryonic endodermal pouches. He presents one case in each category. One case had a slender duct at each end of a large pouch connecting it to both the skin and pharynx. Another case had only a single tract leading from the pouch to the pyriform sinus. The third case was an unusual museum specimen with a long slender sac arising from the lowest part of the pharynx.

Atkinson[2] divides lateral pharyngeal diverticula into three groups. The first are really pharyngoceles produced by prolonged excessive pressure on anatomic weak spaces in the lateral wall of the pharynx. These are seen, for example, in glass blowers. Whitehouse and Holt[14] recently described a similar hypopharyngeal ballooning in congenital choanal atresia. The second type is found in convicts of the Central and United Provinces of India. They are artificial pouches in the lateral pharyngeal wall which are manually produced as hiding places for coins. They are self-inflicted by pressure on the wall of the hypopharynx and are kept patent by digital massage. The third type, which Atkinson considers the rarest, is of congenital origin.

The symptoms of lateral pharyngeal diverticula were described by Buckstein[4,5] as longstanding dysphagia and regurgitation. A most unusual symptom mentioned by Jackson and Jackson[9] is the appearance of suffocative attacks during swallowing if the diverticulum extends into the pyriform sinus. In the case presented at this time the symptoms were intermittent and extended over almost a lifetime. The opening into the pouch could be visualized on inspection of the pharynx.

Posterior Diverticula. In addition to the well known Zenker's diverticulum, Palmer[11] notes that two other types of pulsion diverticula may be found in this area. These are through two poorly understood regions of muscle weakness called Killian's space and Laimer's space. They are located, respectively, 2 centimeters above and 1 centimeter below the weak area through which a Zenker's diverticulum occurs. An extremely rare form of posterior diverticulum was described by Brintnall and Kridelbaugh.[3] It was congenital in origin, being found in 2 infants who presented the symptoms and roentgen findings of esophageal atresia.

Anterior Diverticula. Anterior pharyngeal pouches are the most infrequent. Although in the earlier days of roentgenology symptomless anterior protrusions were occasionally found during a barium study, it is felt that they represented nothing more than well formed vallecular fossae.[2] While this type of diverticulum is common in some animals, it is exceedingly rare in humans. Hurst and Briggs[8] reported an often quoted case in a fifty-seven year old woman. It is not known whether this was an acquired pulsion type or a true congenital defect. Dunhill[6] mentions a case in a two year old child, but it is not described in detail.

SUMMARY

Although lateral pharyngeal diverticula are rare they should be considered in the differential diagnosis of dysphagia, especially in those cases in which the symptoms

are of long duration. A classification of pharyngeal diverticula has been presented to include the more unusual types.

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MULTIPLE PHARYNGEAL AND ESOPHAGEAL DIVERTICULA, HIATAL HERNIA OF THE STOMACH, AND CHALASIA OF ESOPHAGEAL CARDIAC JUNCTION

CASE REPORT

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BECAUSE of the unusual association of a pharyngeal diverticulum, multiple esophageal diverticula and a hiatal hernia of the stomach associated with chalasia of the esophageal cardiac junction, the following case seemed worthy of reporting.

CASE REPORT

The patient, S.R., was a white female sixty-five years of age. During swallowing she noted discomfort in the left side of her throat and a peculiar crackling noise which was audible to to people around her.

Physical examination (by M.E.) revealed the ears, nose and paranasal sinuses to be normal. An elongated uvula was visualized. There was a hypertrophied left lingual tonsil.

Roentgen study included fluoroscopy of the neck and chest. This was followed by a fluoroscopic and film evaluation of the swallowing mechanism, pharynx, esophagus and proximal stomach after oral administration of barium-water mixture.

During fluoroscopy, abnormal air accumulation was visualized in the posterior inferior left hemithorax with an adjacent air fluid level. This suggested abnormality of the distal esophagus and the possibility of a hiatal hernia of the stomach. Appropriate film studies were made (Fig. 1).

FIG. 1. Lateral study of chest demonstrating air fluid level in posterior inferior hemithorax due to gastric hernia.

FIG. 2. Lateral film of cervical region exhibiting air accumulation in pharyngeal diverticulum.

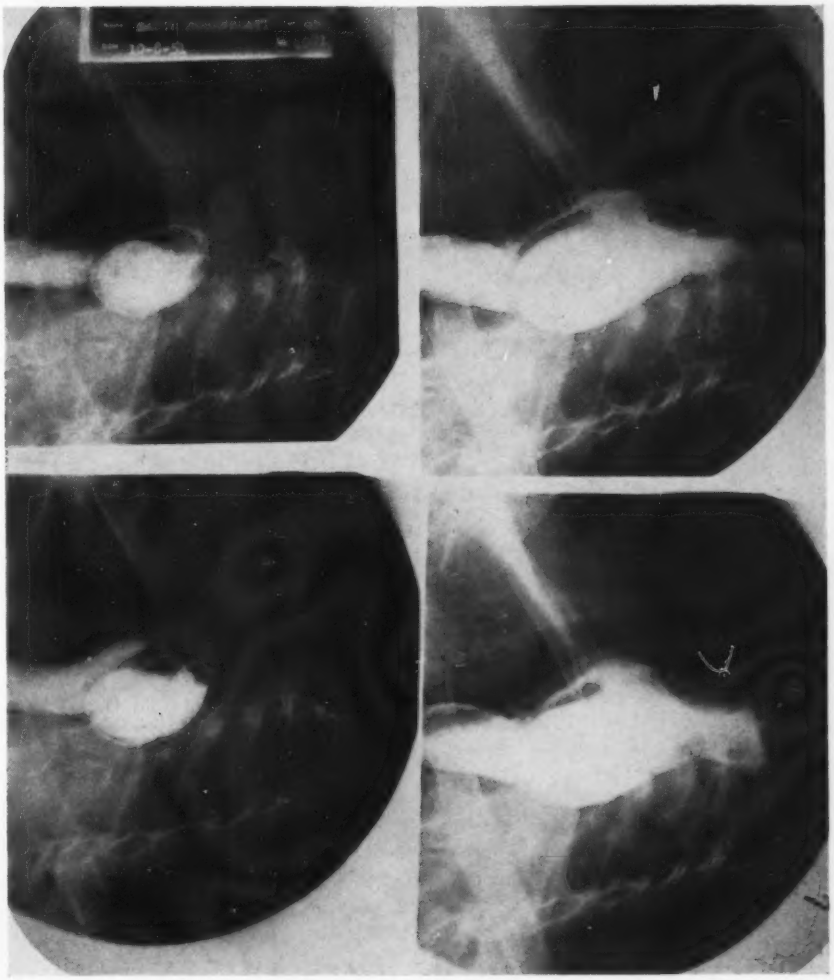

Fig. 3 Barium accumulation in pharyngeal diverticulum.

After swallowing of a water barium mixture, roentgen examination revealed a large diverticulum originating from the posterior lateral aspect of the hypopharynx. This diverticulum measured 3 by 5 cm. in diameter, was dependent, with its orifice oblique in axis and variable in size. It indented the adjacent cervical esophagus and trachea. This represented a pharyngeal diverticulum of the Zenker type (Fig. 2 and 3).

Two additional esophageal diverticula were visualized originating at the level of the aortic arch. One projected anteriorly and one posteriorly. These were of the traction type (Fig. 4).

Another diverticulum of the epiphrenic type was demonstrated extending from the anterior aspect of the distal esophagus (Fig. 5).

Distal to this, the esophageal cardiac junction was visible in the thorax, due to the presence of an esophageal type hiatal hernia of the stomach. This hernia measured 9 cm. in maximum diameter. There was relaxation of the esophageal cardiac orifice and reflux of the barium water mixture from the stomach into the lower esophagus. This represented chalasia of the distal eophagus. (Fig. 6)

DISCUSSION

The occurrence of these multiple lesions in one patient is rare. Their presence suggests that there is a primary muscular weakness in the pharynx, esophagus and right hemidiaphragm. With repeated rise in intraluminal pressure diverticula of the

FIG. 4. Study of esophagus demonstrating pharyngeal diverticulum, and esophageal diverticula in carinal region.

pulsion type, such as in the pharynx and at the epiphrenic level of the esophagus, develop. Traction factors are primarily significant in the development of the mid-esophageal diverticula.

In the development of these diverticula, particularly those in the pharynx, there is a change in their longitudinal axis as well as in the axis of their orifices which is clinically significant. Early in their development, their axis is horizontal with the orifice vertical; emptying occurs, readily, and there is no pressure on the adjacent pharynx or esophagus. Gradually they change from a horizontal to a vertical position with increasing pressure on the pharynx and esophagus. The orifice becomes increasingly oblique to horizontal. As a result, emptying does not readily occur and the pressure causes obstructive phenomena. In this latter stage, surgical excision is primarily indicated.

Pharyngeal diverticula at the pharyngo-esophageal junction are pulsion diverticula and usually orginate at a point of weakness. Their walls consist of mucous membrane, submucosa and a few strands of muscle fibers. Symptoms vary with the size and axis of these diverticula. Dysphagia and

FIG. 5. Visualization of epiphrenic diverticulum of esophagus and gastric hiatal hernia.

FIG. 6. Demonstration of gastric hiatal hernia.

regurgitation of food and mucus are common. The crackling sound present in this patient was apparently related to the compressional effects of swallowing upon the air and mucus trapped in the diverticulum.

Traction is usually the cause of mid-esophageal diverticula. Traction follows inflammatory changes in the mediastinum with resultant scarring and adhesions. Since they retain a horizontal axis with a large lumen, they empty readily. They are usually asymptomatic but can on occasion cause midthoracic burning or even dysphagia. Rarely does ulceration or perforation occur.

Epiphrenic diverticula are uncommon, are pulsion in type and seldom cause significant symptoms. The occurrence of an epiphrenic diverticulum in this case suggests a relationship to malfunction of the inferior esophageal constrictor. With hiatal hernia and relaxed diaphragmatic esophageal ligament, as well as the accompanying hypotonic inferior esophageal constrictor, regurgitation and peptic esophagitis may result. The resultant malfunction of the lower esophagus may predispose to the protrusion of pulsion diverticula from the epiphrenic region.

CONCLUSION

This case presents multiple pharyngeal and esophageal diverticula with a hiatal hernia of the stomach and chalasia of the esophageal cardiac junction.

This association suggests that a congenital muscular weakness is a significant causative factor.

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THE LOWER ESOPHAGEAL RING

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TWO years ago we published a paper describing a series of patients who suffered from dysphagia due to a diaphragm-like narrowing in the lower part of the esophagus. Both the symptoms and the roentgenologic findings suggested that this ring was a definite entity, although its anatomical substrate was not known.

This report will include our experience during the past two years. The existence of the roentgenologic and clinical entity of such a ring appears confirmed. The anatomical nature of the ring, however, has not been established.

HISTORICAL BACKGROUND

Ring-like notching in the lower esophagus has been seen and described as an incidental finding by various authors. Templeton[11] gave an excellent description and illustration of the notching as it occurred in the distended ampulla of the esophagus. Similar observations have been made by Jutras, Levrier and Longtin,[6] Johnstone[3,4] Evans[1] and Poppel, Zaino, and Lentino.[9] Various theories were advanced to explain the ring. Some felt that it was due to the contraction of the inferior esophageal sphincter,[9] represented a mucosal fold,[6] or the insertion of the phrenoesophageal elastic membrane;[1] others felt its origin was unknown.[3,4,11] No symptoms were attributed to the existence of this narrowing.

Since 1947, we have seen in increasing numbers patients with dysphagia apparently caused by a diaphragm-like narrowing of the lower esophagus which simulated the notching described by Templeton[11] in the distended ampulla of the esophagus. We withheld publication until 1953,[10] when Ingelfinger and Kramer[2] reported their own experience on similar cases.

DEFINITION AND DESCRIPTION OF THE LOWER ESOPHAGEAL RING

The lower esophageal ring is a more or less symmetrical, thin diaphragm which protrudes into the lumen of the lower esophagus in a plane which is vertical to the longitudinal axis of the esophagus, approximately 4 to 5 cm. above the diaphragm (Fig. 1 and 2). The ring is quite thin, about 4 mm. thick. There is usually a sharp, nearly right angle between the surfaces of the ring and the walls of the esophagus. This is particularly obvious when the esophagus above and below the ring is well distended. The ring has certain flexibility and acts like an elastic rubber membrane. Solid food pushes the free edge of the ring downward in the longitudinal axis of the esophagus, thereby increasing the diameter of the opening to a certain degree (Fig. 3 and 4). If, however, the diameter of the solid object, for instance a barium filled gelatin capsule, is considerably larger than the opening of the ring, the elasticity is not sufficient and the object is held above the ring. Obviously the same mechanism causes the patient's dysphagia. A similar diaphragm-like structure is more frequently seen in the patients without dysphagia, usually with a wider opening of the ring (Fig. 5).

The diameter of the opening in the ring varies considerably from case to case. The extremes that we have seen range from 3 to 38 mm.* In a given case, however, the *maximal* diameter of the barium distended

* Diameters of the ring as given in this paper refer to the *maximal* diameter of the ring in the barium distended esophagus. They are measured on spot films without consideration of magnification by the divergent beam. Magnification varies from 25 per cent to 33 per cent, i.e., a ring, actually 10 mm. wide, would measure 12.5 mm. in a thin person, and 13.3 mm. in a heavy person, a difference which is negligible. For comparative evaluation, measurements of spot films are therefore adequate.

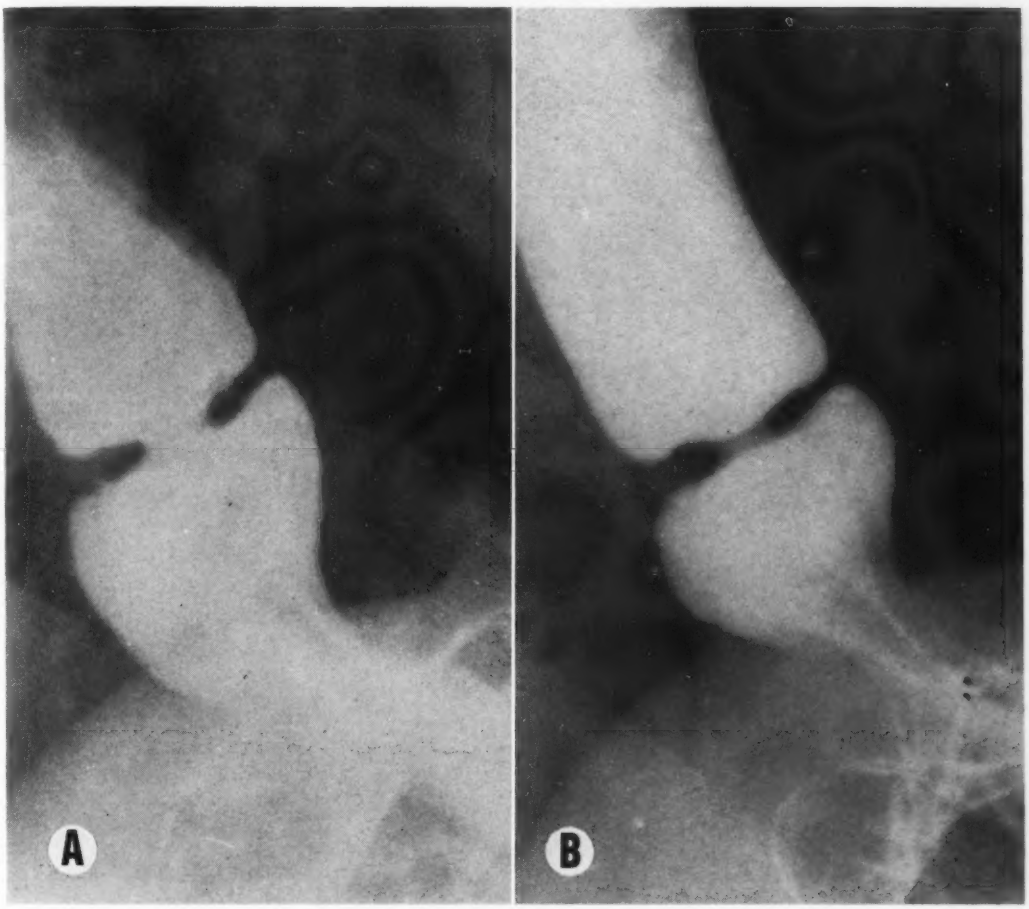


Fig. 1. Five year follow-up of symptomatic ring. Note persistent shape and diameter of ring (8 mm.). K.H., male, aged thirty-eight. (*A*) Short episodes of dysphagia (meat, bread, pills) nine and one half years' duration. (*B*) Five years later. Still occasional episodes of transient dysphagia when he forgets to take small bites and to chew carefully. Not much bothered by it. Has learned to "live with it." (Case 3 of previous publication.[10])

esophagus is constant during any given examination, although the ring sometimes decreases in diameter with the contraction of the esophagus. With the exception of one case in which there was a 3 mm. decrease in the maximal diameter of the ring in nearly eight years, the diameters of the symptomatic rings did not change in later observations, including 2 patients with five year follow-up (Fig. 1). An equal consistency has been true for the majority of the asymptomatic cases. In a few asymptomatic cases the opening of the ring either increased slightly or decreased in the interim between examinations.

In the previous publication it was left undetermined as to whether the rings in patients with dysphagia were of the same nature as the rings in patients without dysphagia. Further observations have shown such a consistent roentgenologic similarity between these two groups that we are more and more forced to the conclusion that the mechanism is the same.

TECHNIQUE OF EXAMINATION

Due to the fact that the ring is only visible if the esophagus is sufficiently distended, it cannot be seen in upright position, except in rare instances. The ring is best seen with the patient horizontal, face down, and partly turned on his

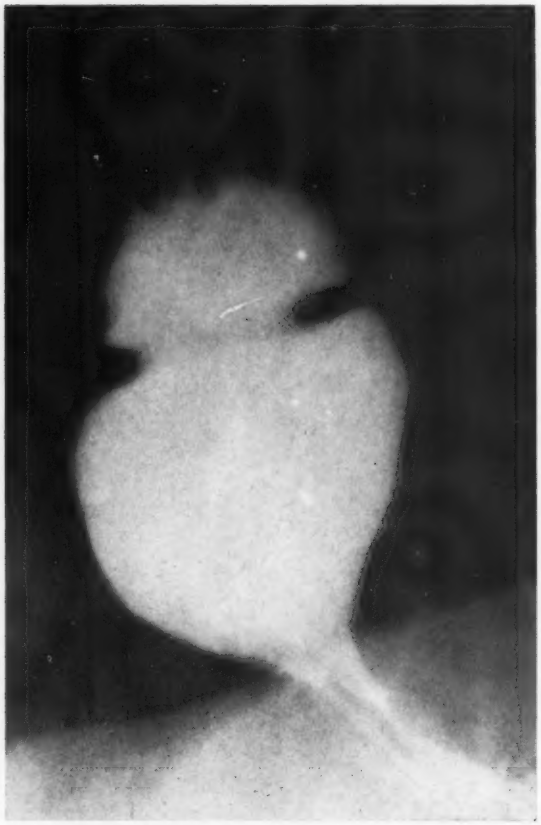


FIG. 2. J.M. Wide symptomatic lower esophageal ring (19 mm.). This is the widest ring which we have observed with repeated episodes of dysphagia. Fifty-two year old man with two to three month history of difficulty when he eats big bites of meat. Feels as if the meat sticks in the lower chest. He waits awhile and then can eat again.

right side. Even in this position there is no delay in the passage of the usual barium-water mixture, and the ring may be missed unless the lower esophagus is sufficiently distended (Fig. 6, 7 and 8). This can be done by having the patient take and hold a deep breath just before the bolus has reached the diaphragm. The Valsalva test occasionally produces further distention, but is rarely necessary. Spot films taken at this moment are of great help, since adequate distention may be so transient that fluoroscopic study of the diaphragm-like narrowing may be difficult.

Obtaining spot films of the distended esophagus is particularly important in patients with dysphagia. The testing of the caliber of the lumen of the esophagus with a barium-filled gelatin capsule is helpful in cases that show no apparent cause for difficulty in swallowing. The largest capsule available for human use is the 000 size which has a diameter of approximately 1 cm. The free passage of such a capsule more or less rules out any lesion narrowing the esophagus to a caliber less than 1 cm. It is also helpful in cases where a ring-like narrowing has been demonstrated with a diameter of less than 1 cm. If the capsule passes through it, a constant organic lesion is highly unlikely and further examination usually shows it to be a transient contraction of the esophagus, and not a ring.

Swallowing of large pieces of food may show the ring very strikingly (Fig. 3). It is, however, always visible without the use of either capsule or food, as long as the lower esophagus is sufficiently distended by the barium mixture.

SEX AND AGE DISTRIBUTION, AND INCIDENCE OF LOWER ESOPHAGEAL RING

We have seen 21 patients with dysphagia due to lower esophageal rings. The cases which we originally reported were all males, as were those of Ingelfinger and Kramer. This is no longer true for our whole group. Eleven were males and 10 were females. At the time of their examinations, only 3 of these 21 patients were less than fifty years old. One patient, a man seventy years of age, maintained that he had had difficulty in swallowing since childhood. In none of the others was dysphagia noticed before the age of twenty-nine, and in the great majority of them not before the age of fifty. In addition we have seen 64 cases showing a ring with no dysphagia; only 10 of these were less than fifty years old at the time of their examination. Many asymptomatic cases were not tabulated during the earlier part of this study.

A better idea of the incidence of both symtomatic and asymptomatic rings can be obtained from a recent series of 368 consecutive patients sent for gastrointestinal

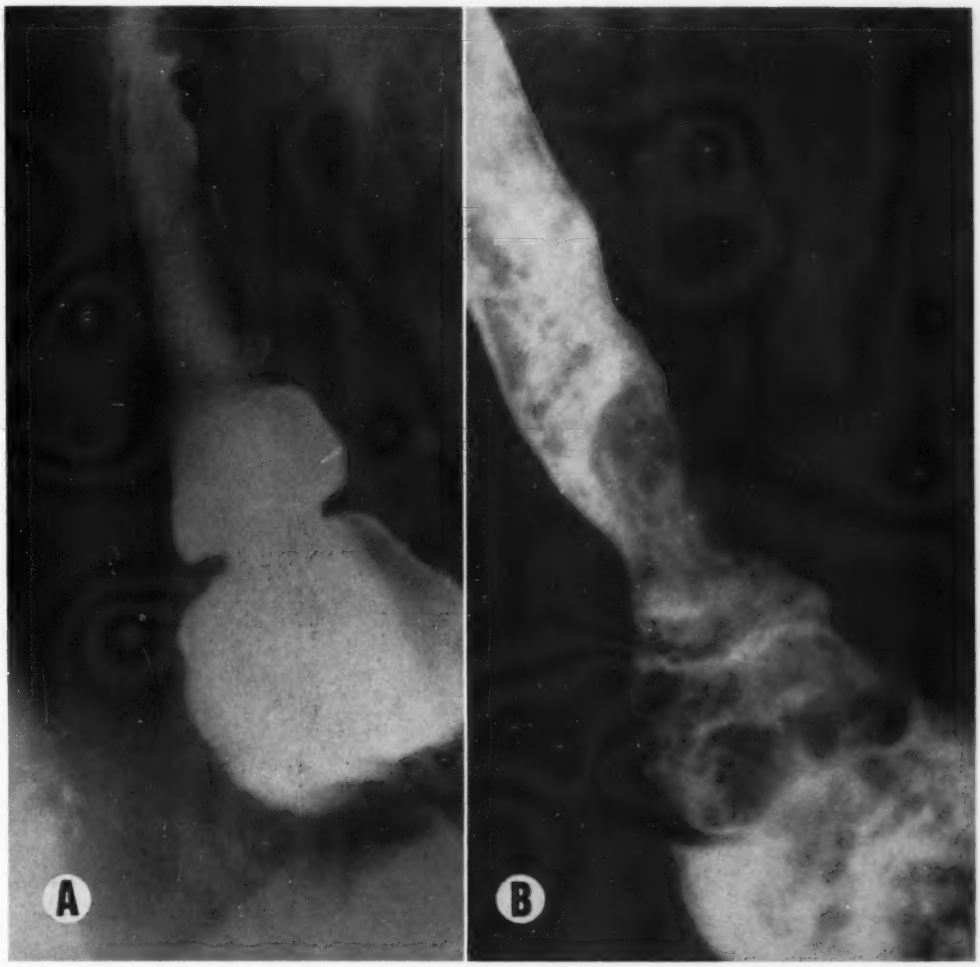


FIG. 3. Downward bending of lower esophageal ring during the passage of solid food. (*A*) Without food. (*B*) Chicken meat passing through the ring bending and stretching it from the 15 mm. resting stage to a diameter of 20 mm. Seventy-six year old woman. Only one episode of dysphagia, four years ago. Some discomfort during food test.

examination in whom a special effort was made to obtain spot films of the maximally distended lower esophagus. Seventeen of these showed a ring; two were found in patients with dysphagia. In this group 185 patients were fifty years or older, and 16 of them had rings (the 2 cases with symptoms were among them). Only one ring was seen in the 183 patients who were less than fifty years old.

SYMPTOMS

The symptoms have previously been described in detail.[2,10] The sporadic nature of dysphagia in most cases is again emphasized. Most of the patients can usually eat without difficulty and have only occasional bouts of obstruction. These episodes, however, may be dramatic and always occur with solids, usually with foods which lend themselves to a large bolus (bread, steak, occasionally potatoes).

Fluids alone will not produce dysphagia but may increase its intensity after a solid piece of food has lodged above the ring.

From an analysis of the cases one must conclude that there is a definite relation between the maximum diameter of the ring and dysphagia (Fig. 9). All of our cases in which the diameter of the ring was less

FIG. 4. Downward bending of the lower esophageal ring as a barium filled gelatin capsule tries to squeeze through the ring. (Case 3 of the previous publication.[10])

than 13 mm. had dysphagia and none with a diameter over 25 mm. had dysphagia. Of the in-between group, the majority had no dysphagia, although an occasional one did. It appears likely that eating habits are of significance in determining whether or not dysphagia occurs in this borderline zone. This is confirmed by the history obtained in a number of patients who had difficulty in swallowing only when they were eating hurriedly. The patients with a rather narrow ring but no dysphagia were usually slow and meticulous eaters.

ENDOSCOPIC AND ANATOMIC FINDINGS

In our previous report[10] the endoscopic findings in 4 cases were described. With the exception of the case with the most marked narrowing in the series (3 mm.) no abnormality was seen. With the narrowest ring a corresponding narrowing was seen in the esophagus, but no other abnormalities were demonstrated. This case came to surgery and the narrowing was confirmed. It was found to be at the herniated esophagogastric junction (Case 1 in previous report). It should, however, be emphasized,

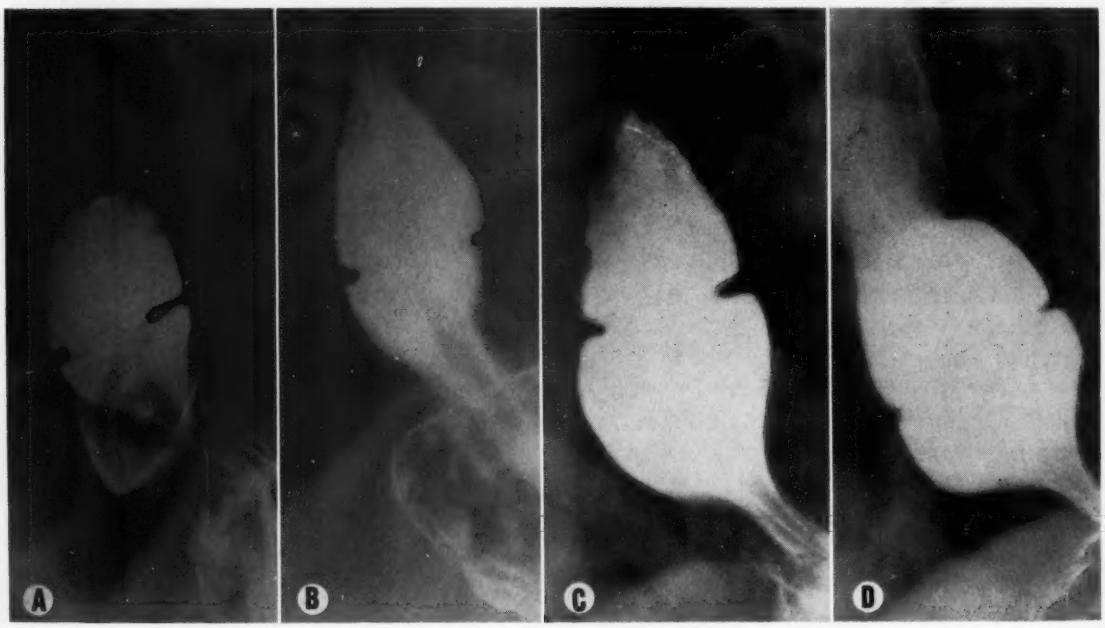


FIG. 5. Four asymptomatic lower esophageal rings. The widest diameters of these four rings were: (*A*) 19 mm., (*B*) 24 mm., (*C*) 24 mm., and (*D*) 36 mm.

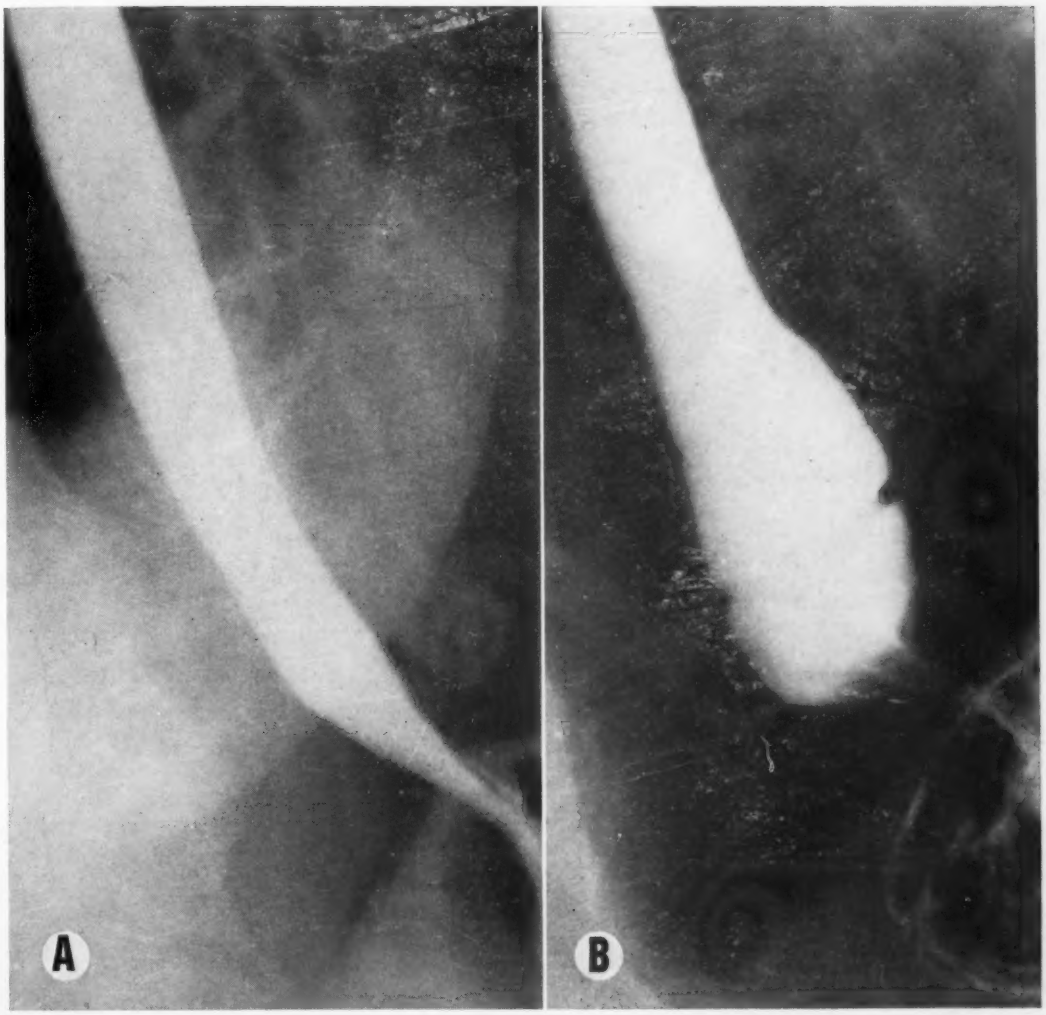


Fig. 6. (*A*) A 21 mm. asymptomatic ring visible only (*B*) when the esophagus is properly distended. Seventy year old woman, no dysphagia.

that in contrast to many other cases with rings, the roentgenologic picture left no doubt that there was herniated stomach immediately below the ring in that particular case.

Unfortunately no additional endoscopic studies have been made on our own cases. In most cases the rings were so classical in appearance that we did not feel justified in asking for corroboration by this means, much as we would have liked to do so. No additional case has come to surgery and we cannot report any autopsy findings.

LOCATION OF RING

During maximal distention of the esophagus, the ring was located about 4 to 5 cm. above the diaphragm in most cases. Ingelfinger and Kramer[2] believe that the ring is within the esophagus, and that the esophagus continues below the ring, and wonder whether it represents the location of the so-called lower esophageal sphincter of Lerche.[7] This assumption has since been accepted by others.[8]

In some of our cases the ring was definitely at the junction of the esophagus and a herniated portion of the stomach. This was proved at operation in one case and in other cases the roentgenologic evidence (shape of the pouch, appearance of the mucosal pattern) seemed to be highly in favor of such

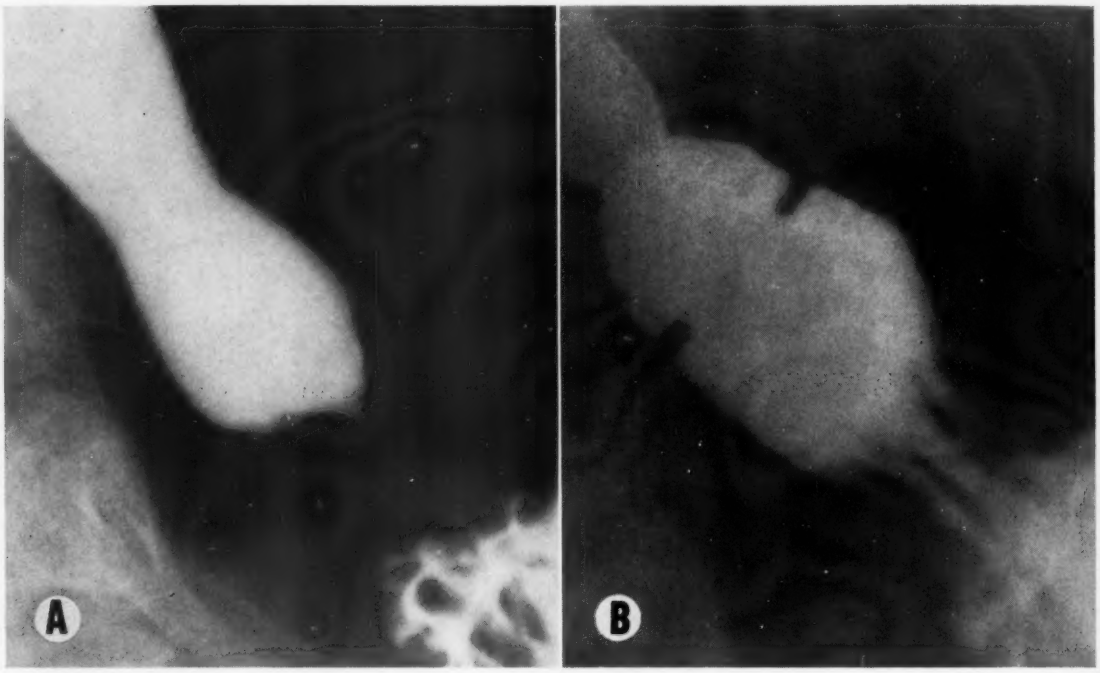


FIG. 7. (*A*) A 25 mm. asymptomatic ring visible only (*B*) when the esophagus is properly distended. Fifty-nine year old woman, no dysphagia. Repeated observations for gastric ulcer. The ring was not noted during the first fourteen months, most likely due to insufficient distention of the esophagus. Two later examinations have shown the ring unchanged.

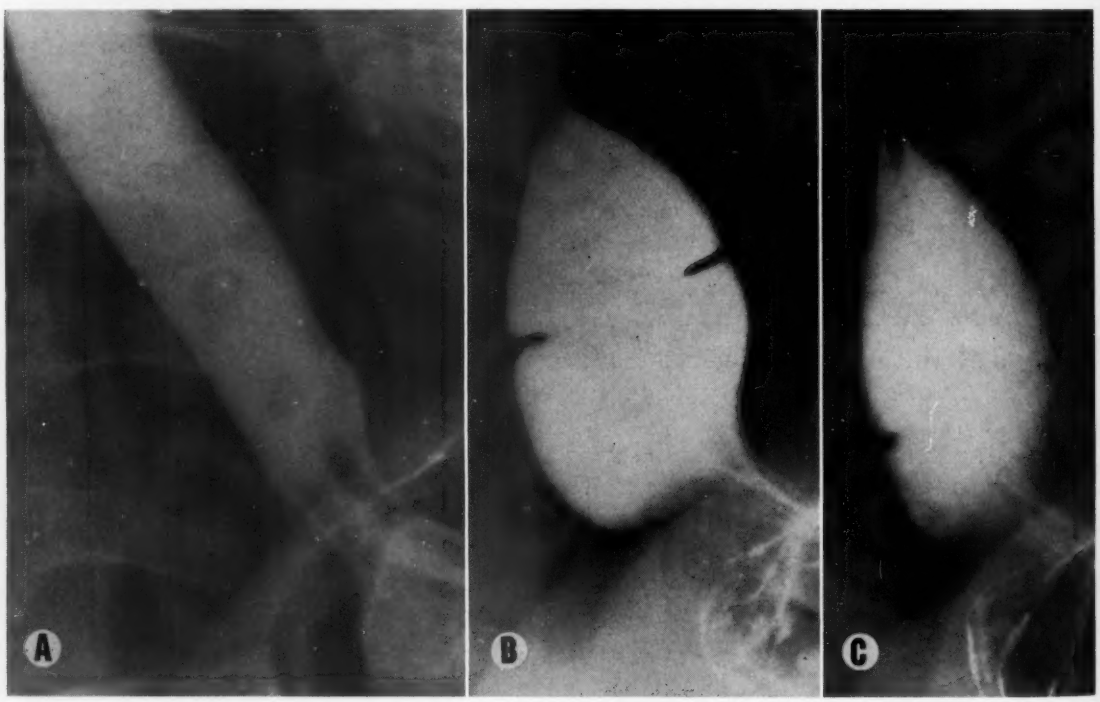
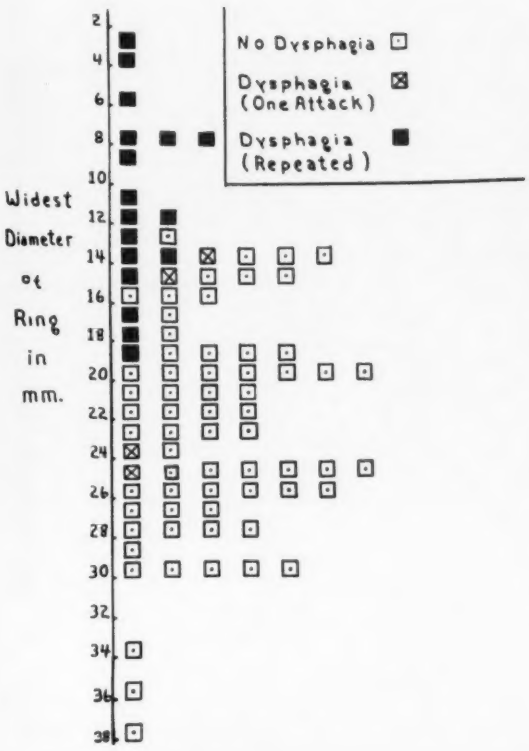


FIG. 8. A 27 mm. ring visible only with sufficient distention of the esophagus. (*A*) Ring not visible due to insufficient distention of esophagus. (*B*) Same day. Ring visible with more distention of esophagus. (*C*) Examination two years later again shows the ring. It has the same diameter. Forty-two year old man, no dysphagia.



a hernia. At times, however, the presence of a hernia was less convincing (Fig. 6). Unfortunately all of the difficulties which pertain to the differential diagnosis of small hiatus hernia arise, and at present we do not know whether the ring is always at the junction of esophagus and herniated stomach, but are inclined to believe that some upwards displacement of esophagus and stomach into the chest is present in all cases.

THE ASSOCIATION OF LOWER ESOPHAGEAL RING WITH DIVERTICULA

Three of our patients with lower esophageal ring had Zenker's diverticula arising from the posterior wall of the lower hypopharynx at the junction with the cervical esophagus (Fig. 10 and 11). One of these

Fig. 9. Chart showing the relationship between dysphagia and the diameter of the rings of the various patients examined. Not all asymptomatic rings were catalogued. See footnote on page 246 in regard to the technique of measuring the diameter.

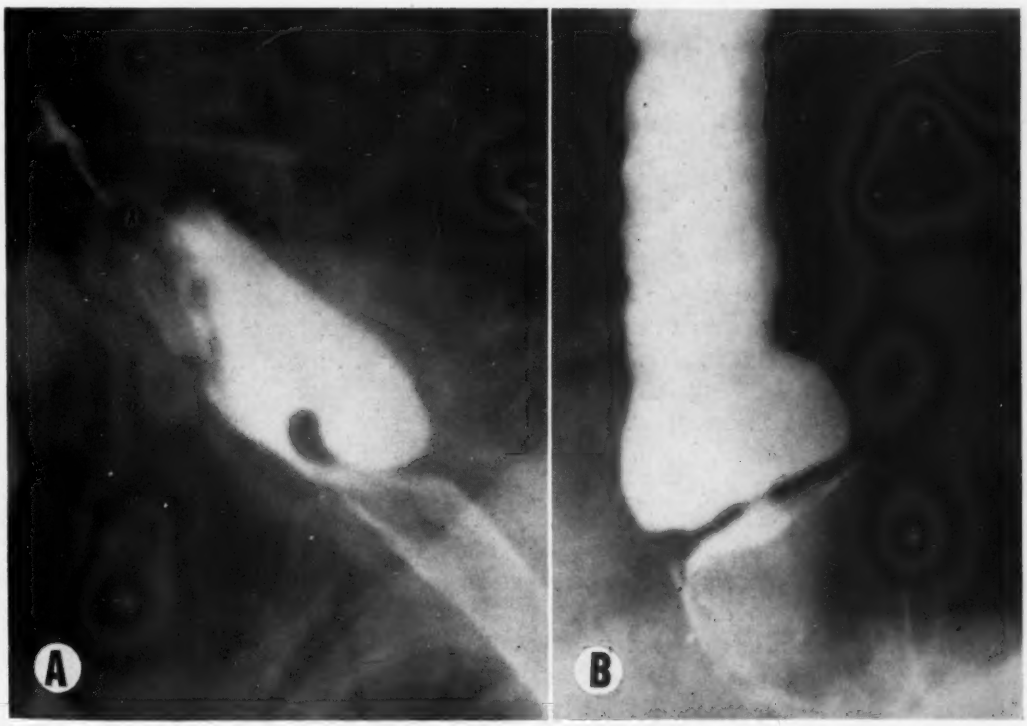


Fig. 10. (*A*) Zenker's diverticulum of the lower hypopharynx in a patient with (*B*) a narrow symptomatic esophageal ring (4 mm.).

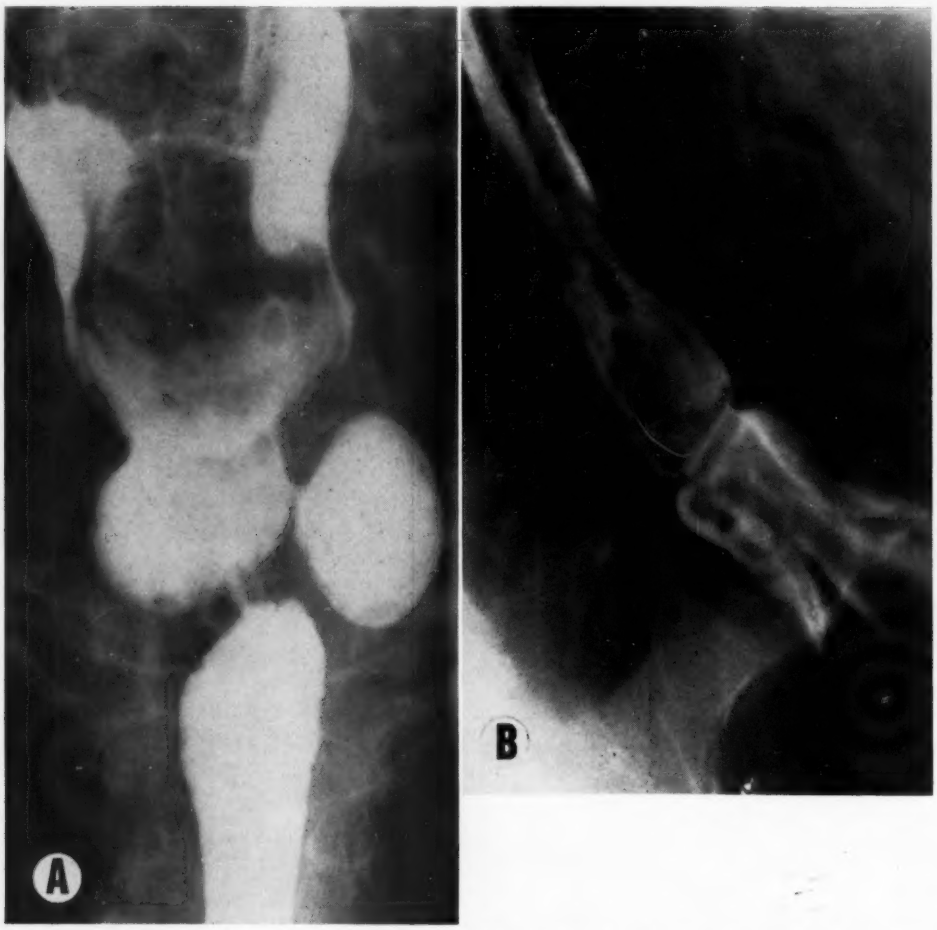


FIG. 11. (*A*) Two posterolateral diverticula of the lower hypopharynx of a patient with (*B*) a lower esophageal ring (?diverticula arising in the triangle of Laimer); 13 mm. ring. Seventy-two year old male. Two year history of solids getting stuck in the throat. Some difficulties with solids in the lower esophagus in previous years. The present symptoms apparently are due to the diverticula and not due to the ring. The old symptoms may have been due to the ring.

patients had two such diverticula (we have never before seen two Zenker's diverticula in one patient, and assume that they originated slightly lateral from the usual position of Zenker's diverticula). A fourth patient with Zenker's diverticulum had a hiatus hernia and a ring-like narrowing above, which possibly could have been due to reflux esophagitis and which for this reason was not classified as lower esophageal ring. All 4 patients had dysphagia. In 3 of them the presenting difficulty was localized in the lower esophagus while in the fourth patient, the one with the two diverticula, the dysphagia was obviously caused by the diverticula. But even this patient mentioned that, in years preceding his present complaints, he had had episodes of dysphagia localized in the lower rather than upper chest.

The frequent association of the rare Zenker's diverticula with symptomatic rings can hardly be due to chance coincidence. Possibly, episodes of increased intraesophageal pressure in dysphagic patients are responsible for the formation of the diverticula.[7]

DIFFERENTIAL DIAGNOSIS

The classical esophageal ring is so characteristic that it does not bear any similarity to other lesions. There is none be-

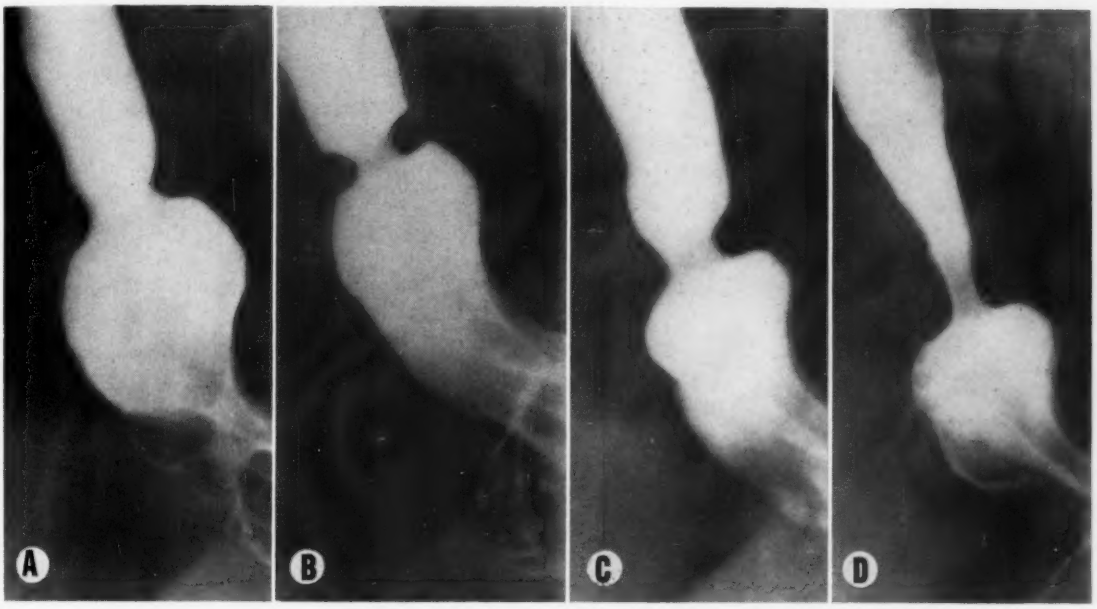


Fig. 12. (*A*), (*B*), (*C*) and (*D*) Annular contraction of the lower esophagus not a ring. (Reprinted from a previous article in this Journal.)

tween the ring and cardiospasm or cancer. As previously mentioned,[10] a superficial similarity to esophageal webs, as in Plummer-Vinson syndrome, is excluded by the location of the ring in the lower end of the esophagus, by the fact that it is thicker than the web, and that there is no anemia. The ring must, however, be differentiated from transient localized contraction of the esophagus. It is shorter than an annular contraction and always has the same length in a given case. The annular contraction changes in length. It becomes longer as the esophagus contracts, and shorter with relaxation (Fig. 12 and 13). An annular contraction changes its location in the esophagus whereas the lower esophageal ring remains stationary, although its distance from the diaphragm may seemingly change with the various degrees of ballooning out of the part between the ring and the diaphragm (Fig. 14 and 15).

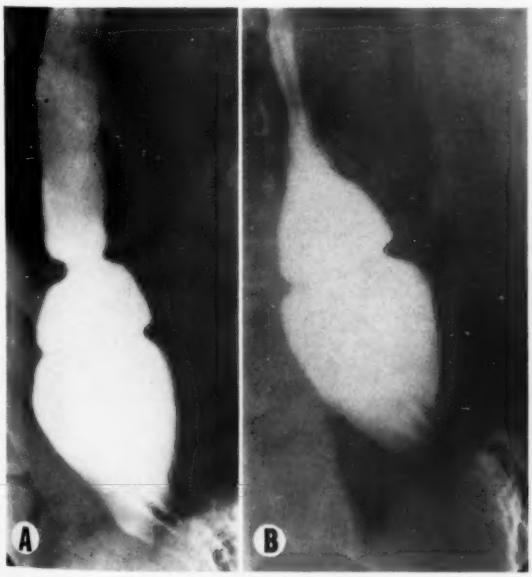


Fig. 13. (*A*) and (*B*) Asymptomatic ring and ampullar contraction, 25 mm. ring.

The differentiation of the ring from the uncomplicated hiatus hernia is a more difficult diagnostic problem (Fig. 16, 17 and 18). The lowermost portion of the esophagus just proximal to a hernia is—even in the absence of esophagitis—commonly somewhat narrow, apparently due to the action of a physiologic sphincter mechanism. The narrowing, however, involves a longer segment than the ring and varies in length and thickness with its contraction. Furthermore, in contrast to the diaphragm-like narrowing of the ring, it is usually cone shaped and occasionally shows a bayonet-like tortuosity. Finally, of course, a hiatus

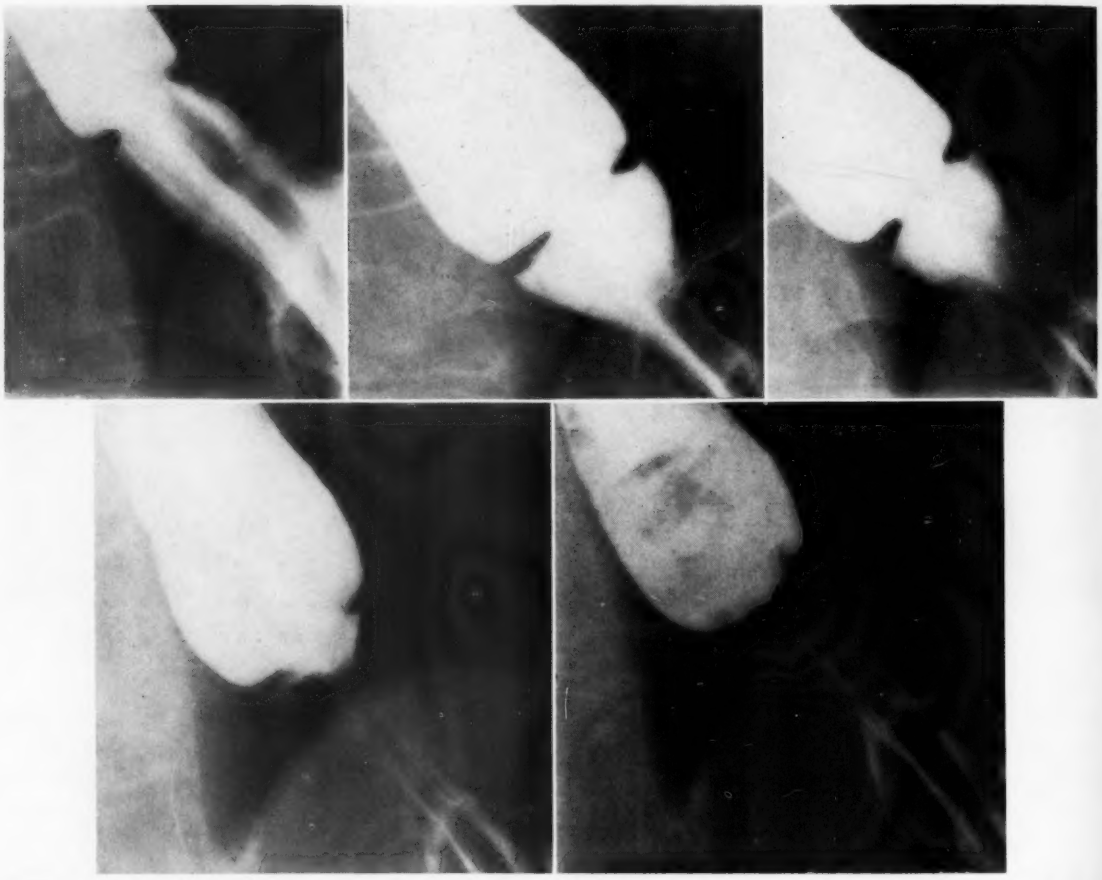


FIG. 14. Pseudomigration of the ring most likely due to collapse of the pouch distal to the ring. Sixty-five year old woman, 13 mm. ring. No symptoms. This is the narrowest ring we have seen without dysphagia. The patient was an unusually slow eater.

hernia *per se* without accompanying esophagitis would not explain the marked constant narrowing and the dysphagia in the symptomatic cases. At times differentiation between hiatus hernia with ring and uncomplicated hiatus hernia is difficult. Doubtful cases were not listed as rings.

Differentiation from esophagitis above a herniated stomach is necessary, particularly when the ring is narrow. The narrowing produced by the ring involves only 2 to 4 mm. of the esophagus. This is considerably shorter than usually seen with esophagitis. It is almost always symmetrical, whereas the narrowing caused by esophagitis is commonly asymmetrical, involving one side of the wall to a greater length than the other (Fig. 19). The surface of the ring is smooth, in contrast to the fine irregularities encountered in esophagitis. All these factors combined permit differentiation from the picture usually seen in esophagitis. Incidentally, those few rings which came to operation or esophagoscopy showed no evidence of esophagitis, ulceration, or scarring.

While we have at present no evidence whatsoever to connect the ring with esophagitis, we cannot completely rule out that the extremely localized but circular restriction in distensibility is due to a thin ring of scarring in the wall below the mucosa. Histologic examination in the future may throw light on this possibility.

The increasing number of patients in whom we diagnose rings has disturbed us, and we have wondered what diagnosis we had made in such cases in the past. Fortunately for this study, a few of these patients had had previous examinations in our department. In some of them, we had frankly

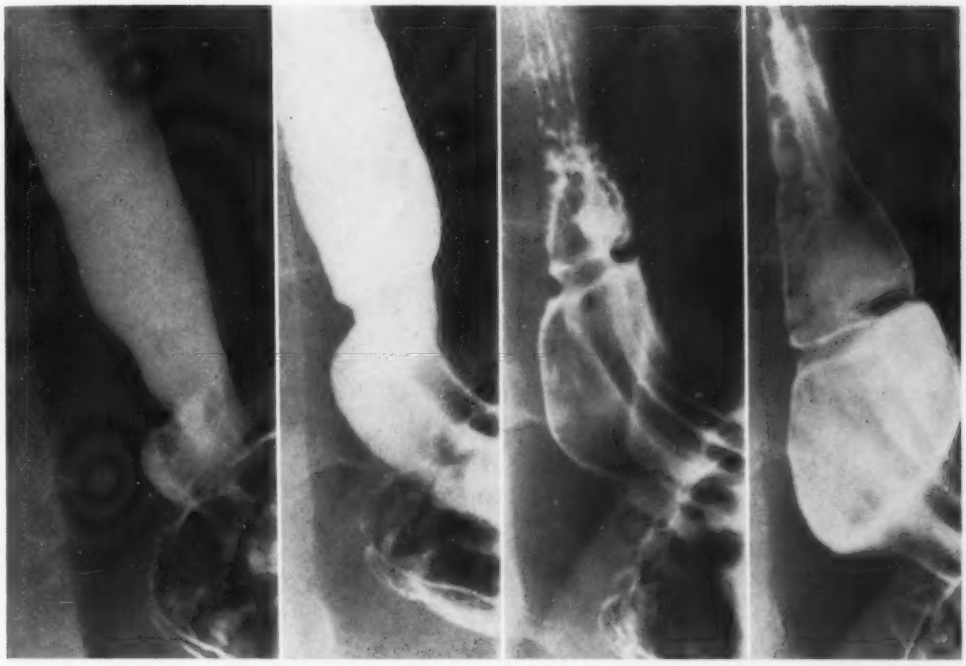


Fig. 15. Pseudomigration of ring most likely due to varying degree of filling of the pouch distal to the ring. The exact phase of respiration on the various spots is not known, but most likely they were all in inspiration. All films were taken on the same day, but possibly not in the sequence in which they are shown. Female fifty-seven years old., 17 mm. ring. Nine year history of difficulty in swallowing meat and occasionally bread.

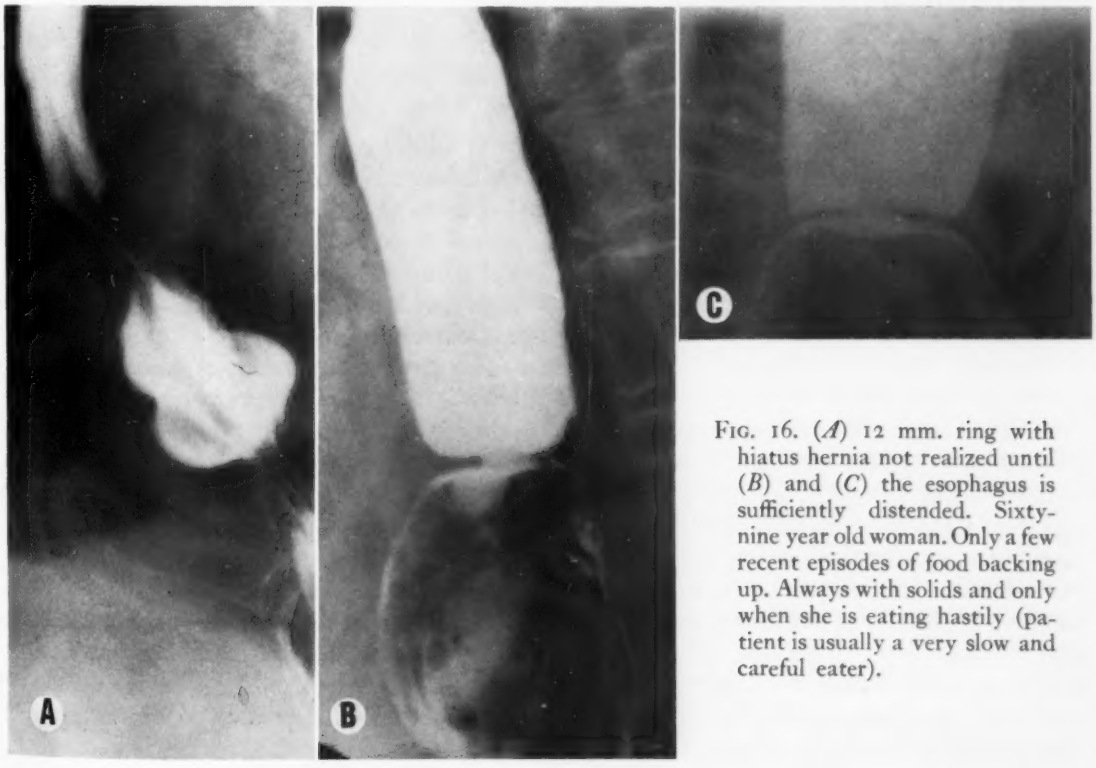


Fig. 16. (*A*) 12 mm. ring with hiatus hernia not realized until (*B*) and (*C*) the esophagus is sufficiently distended. Sixty-nine year old woman. Only a few recent episodes of food backing up. Always with solids and only when she is eating hastily (patient is usually a very slow and careful eater).

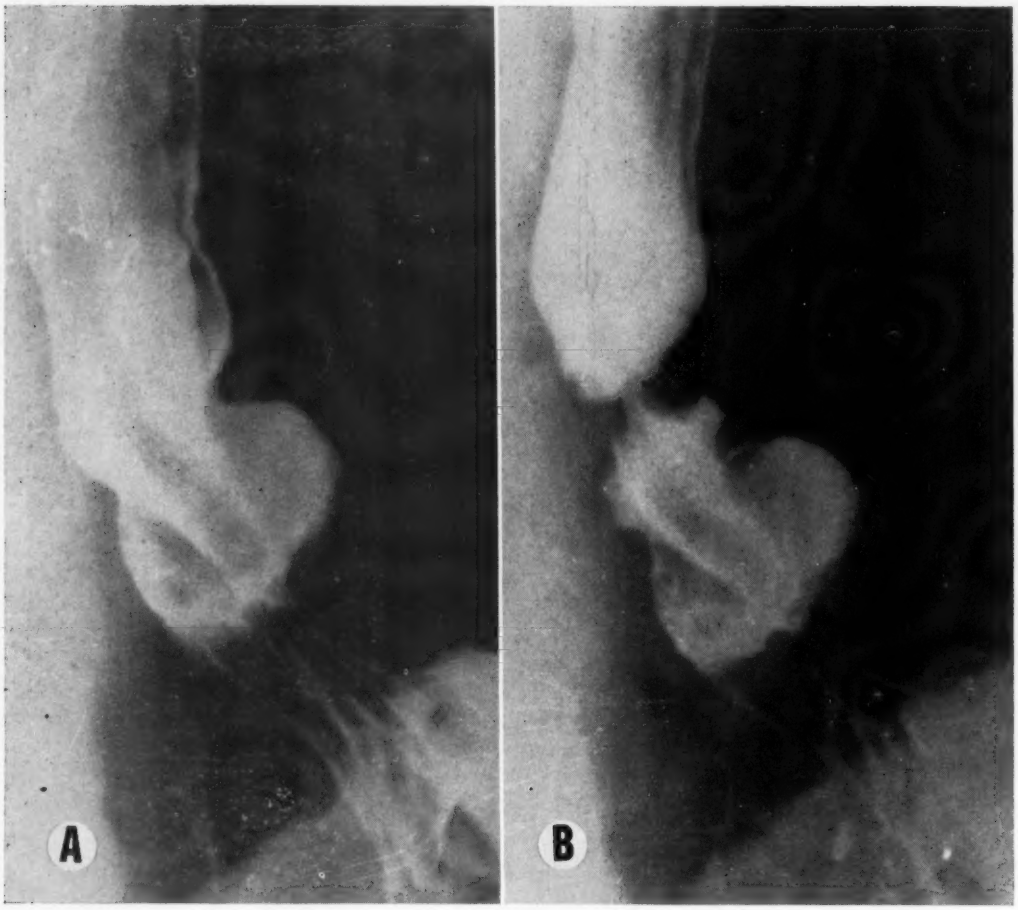


FIG. 17. (*A*) Small hiatus hernia (*B*) showing, in contrast to the ring, the inconsistent narrowing above the pouch. No dysphagia.

missed any abnormality; in others, we had been satisfied with the diagnosis of small hiatus hernia and had not recognized the inability of the very short segment of esophagus immediately above the stomach to dilate sufficiently.

NATURE OF THE RING

Only one of the published cases of Ingelfinger and Kramer[2] and one of our cases[10] came to surgery. In the case of Ingelfinger and Kramer, no hiatus hernia was seen. There was thickening of the longitudinal and circular muscle layers at the site of the narrowing. The mucosal lining was esophageal. In our case, a definite hiatus hernia was found at thoracotomy. Its presence was confirmed by opening the herniated portion of the stomach. A biopsy of the ring itself showed esophageal mucosa. No biopsy of muscle was obtained. No thickening or increased firmness was palpable at the site of the ring although the undersurface of the ring could be clearly seen through the gastrostomy.

These two observations are contradictory. They do, however, not necessarily indicate a different mechanism for the 2 cases if one realized the difficulty of identifying the exact site of such a ring at the time of operation and in the specimen.

In the absence of more abundant operatively checked material, a discussion on the nature of the ring must be based primarily on an analysis of the roentgenologic appearance and behavior of the ring. An effort to correlate it with the normal anatomy and and physiology of this region is tempting.

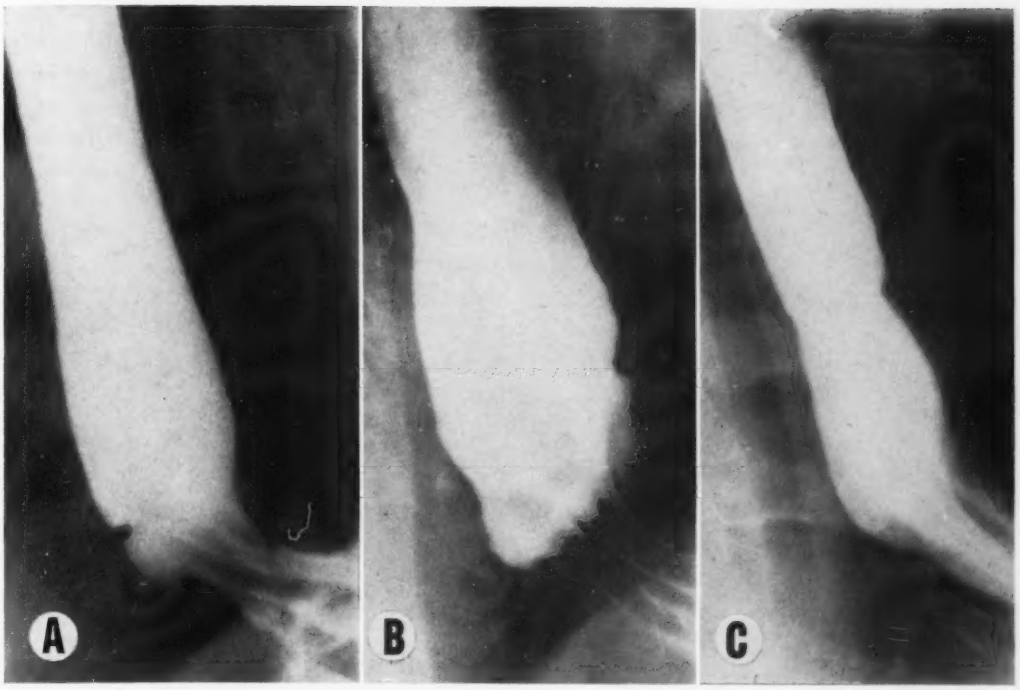


Fig. 18. (*A*), (*B*) and (*C*) The lower esophagus in 3 different patients. Appearance simulates ring, but does not completely fulfill the criteria laid down for rings. These may possibly be rings, but they were not classified as such in this study.

Unfortunately, there is no agreement in regard to the normal anatomy of the lower esophagus and the closing mechanism of the upper end of the stomach. The contradictory opinions of various authors are excellently described in Templeton's summary.[11] Most authors agree that the lowermost esophagus forms a pouch which anatomically and most likely physiologically is different from the rest of the esophagus. There is, however, disagreement, whether there is one such pouch or whether there are two pouches in succession, and there is disagreement in regard to the role which the diaphragm and the musculature of the lower end of the esophagus play in the closing mechanism of the stomach.

In recent years, the "two pouch" theory has found more supporters, mainly due to the monograph of Lerche.[7] In dissections of 100 esophagi, Lerche found two pouches, separated by a circular muscle, the so-called lower esophageal sphincter. He described another circular muscle, the constrictor cardiae, at the lower end of the lower pouch immediately above the stomach. The existence of such a constrictor has been denied by others.

Ingelfinger and Kramer[2] believe that the ring represents an abnormal contraction ring and postulate that an overactive lower esophageal sphincter which clamps down on the food may be the cause of the roentgenologic and clinical picture. Others[8] are inclined to agree with these authors.

In our experience the ring has not acted like a contracting sphincter but rather like a passive structure. Due to the absence of such a sphincter mechanism, the ring is inconspicuous in the nondistended esophagus (Fig. 6, 7 and 8). The ring does not clamp down on the food but is widened passively as the food tries to squeeze through the opening of the ring (Fig. 3 and 4). The previously mentioned bending and stretching of the ring which occurs at this moment is difficult to connect with the presence of an overactive sphincteric muscle, as is the fact that the maximal diameter of the ring in a given person remains more or less con-

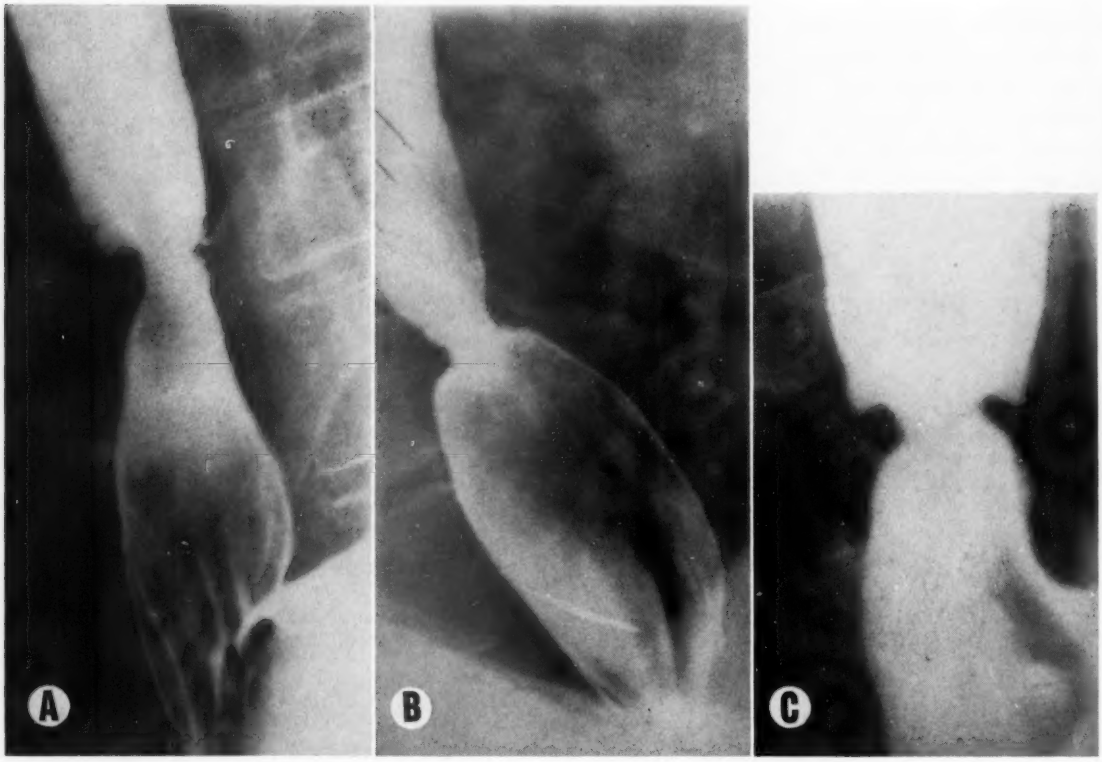


FIG. 19. (*A*), (*B*) and (*C*) Three cases of esophagitis confirmed by esophagoscopy, 2 also by operation. Note the greater and unequal length of the involvement around the circumference of the esophagus as compared with the short symmetrical narrowing of the lower esophageal ring.

stant over several years.

In our opinion, the ring represents a short annular segment of the lower esophagus which for some reason cannot be distended as well as the structures above and below. This localized decrease in distensibility is the most characteristic and clinically significant feature of the ring. We do not know the nature of the restraining mechanism. We agree with Ingelfinger and Kramer that it may be muscular in nature, but believe that, at least in the symptomatic cases, a constant alteration takes place, either due to hypertrophy, change in tonus, or scarring, and that the ring does not represent the intermittent contraction of a muscle.

Whatever the restraining mechanism may be, it appears in some way connected with herniation. A ring is frequently found immediately above a herniated portion of stomach, and some upward movement of the intestinal tube probably has taken place in all cases with rings.

Further roentgenologic studies in conjunction with planned esophagoscopic, surgical, and anatomic follow-up studies are likely to give an answer in regard to the nature of the ring. The solution of this problem would probably represent a stepping stone helpful for a better understanding of other problems involving the junction of esophagus and stomach.

TREATMENT

The nature of the ring is still quite problematic, but the roentgenologic and clinical picture in symptomatic cases forms a definite entity which requires treatment of the patient. Fortunately the treatment is considerably less problematic than the nature of the ring. Since it appears that the patient will have dysphagia only if there is a discrepancy between the known size of the ring and the size, and to a certain degree the consistency of the bolus which he

swallows, it is necessary to inform the patient of the nature of his lesion. He is to understand the necessity of eating slowly and of decreasing the size of the bolus. The scare which so frequently overtakes these patients during a sudden attack of choking disappears with the knowledge of the mechanism. The majority of our patients with a long follow-up told us that they still had occasional difficulties in swallowing, but less frequently and not severely. Attempts at changing the narrowing pharmacologically and by bouginage have been made only in a very incomplete way. They were not successful. A very narrow ring may require plastic surgery.

SUMMARY

1. A thin diaphragm-like constriction of the lower esophagus is not infrequently found if the lower esophagus is distended with a barium mixture (lower esophageal ring). The esophagus may appear completely normal unless it is sufficiently distended. Occasionally this diaphragm is still clearly visible in the collapsed esophagus.

2. This narrowing represents a thin annular portion of the wall of the esophagus which cannot be distended as well as the wall above and below this region.

3. The *maximal* diameter of the ring is usually constant for several years.

4. The ring occurs equally frequently in males and females. It is considerably more common in persons past the age of fifty.

5. The ring must be differentiated from simple muscular contraction of the esophagus and from hiatus hernia with or without esophagitis.

6. The cause of the ring is unknown. The ring is frequently associated with a hiatus hernia, and it appears likely that some upward displacement of the intestinal tube into the chest is present in all cases with rings.

7. In most instances the ring produces no clinical symptoms; in a smaller group of persons it results in dysphagia with characteristic sporadic episodes of difficulty in swallowing solid food.

The authors observed 21 patients with dysphagia. The question of whether or not dysphagia occurs depends primarily on the diameter of the maximally opened ring and to a lesser degree on the eating habits of the patient.

8. Satisfactory therapeutic results in the patients with dysphagia can usually be obtained by proper education of the patient. An occasional case will require surgery.

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EVALUATION OF THE VARIOUS METHODS OF DEMONSTRATING A HIATUS HERNIA

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BY FOLLOWING a definite and prearranged sequence of positions and maneuvers 35 hiatus hernias were found in 1,500 consecutive gastrointestinal examinations. A number of papers have appeared in the medical literature on the subject of hiatus hernia during the past twenty-five years and the importance of radiological methods in the diagnosis of this condition has been stressed repeatedly. Some writers have indicated the use of various supplementary procedures for demonstrating a hernia when it was not demonstrable during a routine gastrointestinal study. No one has compared these methods and procedures on a statistical basis in order to determine the effectiveness of each.

With this fact in mind it was decided that special effort be made to determine the existing number of hiatus hernias in 1,500 consecutive gastrointestinal examinations. It was planned that each fluoroscopist would carry out in a definite sequence all of the positions and maneuvers which had been described by various authors. This was done on all of the patients examined during the study with the exception of 25 whose physical condition did not, at that time, permit any special procedures.

Past experience of those conducting the study, together with a review of the literature, was convincing evidence that the clinical diagnosis of hiatus hernia was inaccurate. It was also known to the investigators that in some instances a hernia could not be demonstrated consistently, even after such a finding had been reported on previous gastrointestinal examinations.

The etiology and symptomatology of hiatus hernia have been thoroughly covered in many publications[2,4,10,13] and need not be repeated here. Treatment has been discussed at length by Harrington and Kirklin,[6] Ritvo[11] and others, and is not relevant to this paper.

From a surgical standpoint, the esophageal hiatus may be evaluated according to its size. Harrington and Kirklin[6] in a study of 1,000 abdominal operations found that in 2 per cent of the patients the esophageal hiatus would admit two to three fingers and 8 per cent admitted two fingers only. Of the remainder 35 per cent admitted one finger and 55 per cent would not admit one finger.

Many classifications of diaphragmatic hernia are available, most of which are based on etiology and the portion of the diaphragm involved. The esophageal hiatus hernia, both congenital and acquired, may be subclassified as concentric or eccentric,[13] depending on the relationship of the lower esophagus to the hernia; or it may be classified as true or false,[3] depending on whether or not the hernia has a peritoneal sac. Kirklin and Hodgson,[9] in their classification, considered the congenitally short esophagus with thoracic stomach as a failure in development, in which the stomach remains in the thorax during fetal development. They also say that in many cases it is impossible to distinguish roentgenologically between a hernia which is the result of an acquired shortening or one due to a congenital short esophagus. Their third category shows no evidence of esophageal shortening, as the stomach herniates together with the esophagogastric junction, and the esophagus becomes redundant. In the paresophageal hernia, a portion of the stomach herniates through the hiatus while the esophagogastric junction remains below the diaphragm and no esophagus is present within the hernia. Acquired shortening of the esophagus, they

state, can be due to mediastinal tumors displacing the esophagus, carcinoma with inflammation and shortening of the esophagus, marked cardiac enlargement with esophageal displacement, and ulcer of the esophagus producing upward traction on the esophagus.

INCIDENCE

The incidence of all diphragmatic hernias varied, according to different authors[3,4,9] from 1 to 3.5 per cent. In 635 necropsies, according to Feldman,[3] Eppinger found an incidence of hiatus hernia in 1.7 per cent. In our series, 2.3 per cent of the upper gastrointestinal examinations revealed a hiatus hernia. In addition, during the period in which the gastrointestinal investigation was being made, 2 such hernias were found on routine chest roentgenograms. One of these was confirmed by subsequent examinations with barium. The other did not return for further study (Fig. 1 and 2).

Fig. 1. A hiatus hernia first seen on routine chest film as a gas bubble above the diaphragm. Subsequent film prior to barium study shows the same gas pattern.

Fig. 2. Same patient as Figure 1, showing both gas and barium in the cardia above the diaphragm.

Most authors are in agreement that hiatus hernia is much more common in the aged. This has been attributed by Harrington[5] to atrophy of the esophagogastric membrane. According to Schatzki, as quoted by Sahler and Hampton,[12] in a study of a small group of patients over sixty-five years of age, 73 per cent of them had a hiatus hernia. Most other reports gave a smaller incidence than this, but definitely higher than in the young age groups. The average age of our patients with hiatus hernia was sixty years. Five (14 per cent) were seventy years of age or older. Only 2 (5 per cent) were under the age of forty-five.

Esophageal hiatus hernia is much more common than other types of diaphragmatic hernia. The incidence according to some

FIG. 3. A small hiatus hernia seen only while the patient was in the supine position and laughing. No other tests demonstrated this hernia.

authors varies from 78 per cent to 98 per cent of the total of diaphragmatic hernias and in our small series it was 97.3 per cent. The literature is in agreement that hiatus hernia predominates in women by about a ratio of two to one. In our series two-thirds of the hiatus hernias were found in women. Pregnancy in particular is a predisposing factor and Rigler and Eneboe, quoted by Golden,[4] report that in their study of pregnant women 18 per cent had a hiatus hernia.

Several authors have suggested procedures to supplement the routine upper gastrointestinal examination in order to demonstrate a hiatus hernia. Jenkinson and Roberts, who found only 5 per cent of their hernias in the upright position, feel that examination in this manner is insufficient to demonstrate most hernias. Kirklin and Hodgson state that they frequently found clues suggestive of hernia while examining the patient in the upright position. These clues are redundancy of the lower esophagus and an unusually tall barium column in the esophagus, when the patient ingests the barium rapidly. For greater accuracy in searching for a hiatus hernia the patient should also be examined in the horizontal position. Some authors preferred the Trendelenburg position,[2,4,7,8] some the prone position[2,10] and others used manual pressure over the abdomen.[8,10] Many suggested that the patient "strain," but Kirklin and Hodgson report that the Valsalva and Mueller experiments were useless in their experience. Some preferred the "strain" and the cough in the upright position, but Kirklin questions the advisability of any straining procedure in order to show a hiatus hernia. No mention of the value of laughter (Fig. 3), belching (Fig 4), or

FIG. 4. A hiatus hernia in a sixty four year old male. Hernia was produced only when the patient belched.

straight leg raising (Fig. 5), was found in the literature. Several authors emphasize the importance of filling the stomach completely.

According to Feldman,[3] the differential diagnosis of hiatus hernia included cardioesophageal patency, diverticulum of the lower esophagus or cardia of the stomach, giant ulceration of the lower esophagus, and phrenic ampulla. Of these the last was the most confusing. Buckstein[2] mentions two important points in differential diagnosis, namely: the presence of mucosal folds in a hernia characteristic of the mucosal folds of the stomach, and the transient nature of the phrenic ampulla. Templeton[13] stated that when the patient strains, the barium in the ampulla regurgitates further up into the esophagus, beyond the constriction at the proximal end of the ampulla, and without straining, the ampulla is not always seen.

Many complications of hiatus hernia have been described.[3,11] In our series only one complication was seen and that was a large ulcer within the herniated portion of the stomach (Fig. 6).

Fig. 5. A hiatus hernia produced only with the straight leg raising maneuver.

Fig. 6. A hiatus hernia in a forty-nine year old female and first seen with the patient in the upright position. Ulcer crater seen only in the supine position when that portion of the stomach containing the ulcer was forced above the diaphragm by straight leg raising.

PROCEDURES

A definite sequence of maneuvers was decided upon and carried out by all examiners. During fluoroscopic examination it was noted which procedure first demonstrated the hernia, and which, if any, subsequent procedures altered the appearance of the hernia. We suspected that certain maneuvers (e.g., Valsalva test and Trendelenburg) were of least value, and therefore we did them immediately following the erect position. This provided these maneuvers with the first opportunity to demonstrate a sliding hernia, so that it could not be said that they would have shown a hernia if it had not already been demonstrated. The Mueller test was not included for two reasons: first, a considerable portion of people were un-

able to perform it; and second, no previous writers had claimed that it was effective. The belch was included for the first hundred examinations or so, but very few patients were able to belch at will. Two hernias were found to increase in size with belching. Ingestion of a carbonated drink to accentuate the gas in the cardia was found to be impractical as it interfered with the routine examination of the stomach. We considered any procedure involving simultaneous filling of the colon as too involved to be practical in the routine upper gastrointestinal examination.

The order in which the various maneuvers were carried out began with the patient in the erect position. The gas bubble in the cardia was examined in the upright position before, during, and after ingestion of the barium. Each patient received a minimum of 8 ounces of barium mixture. Next the table was lowered to the horizontal and then into 15° Trendelenburg position and the abdomen palpated. The patient was then requested to perform the Valsalva test (after instruction), and following this he performed the straight leg raising maneuver in which he was requested to lift both heels off the table and breathe at the same time. This "straight leg raising" maneuver, as we term it, appears strenuous, but an insignificant number of people were unable to do it. Following this the patient was instructed to relax and was then rotated to the right lateral position and then to the prone position. When a hernia was first demonstrated the finding was immediately verified by taking one or more films.

A hiatus hernia was found without special procedure in one of the 25 patients who were not subjected to any of the maneuvers. The diagnosis of esophageal hiatus hernia was suspected clinically in only a few of the cases in which a hernia was demonstrated, but in a substantial number in which a diaphragmatic hernia was given as the clinical diagnosis no abnormality of any kind was found.

Presumably a hiatus hernia is produced by an increase of the intra-abdominal pressure, resulting in a protrusion through the weakest area of the diaphragm. This is borne out by the frequency of diphragmatic hernia in cases of obesity and pregnancy. However, increased intra-abdominal pressure need not be the only factor. Conditions producing upward traction on the distal esophagus and thereby pulling the stomach through the esophageal hiatus have already been cited.

Many hiatus hernias, especially the so-called sliding type, are spontaneously reduced when the intra-abdominal pressure is decreased, and obviously this is the reason they are frequently not visible. It appears logical that any maneuver which would markedly increase intra-abdominal pressure while at the same time decreasing or not changing intra-thoracic pressure would force a potential or reduced hernia through the esophageal hiatus.

When a person stands upright and breathes quietly, there is very little difference in pressure above and below the diaphragm and for that reason many hernias cannot be shown in the upright position. Theoretically, the Trendelenburg position should aid in demonstrating a hernia but in this series none were demonstrated initially in that position.

It follows that the most likely means of demonstrating a hernia is to increase intra-abdominal pressure, but only in so far as it increases the difference in pressure above and below the diaphragm. The Valsalva experiment increases intra-abdominal pressure markedly; however it also increases intrathoracic pressure, since the patient is straining against a closed glottis. Therefore, the difference in pressure above and below the diaphragm is negligible. When the patient coughs, essentially the same thing occurs. The most effective maneuver was straight leg raising. To maintain the weight of the lower extremities the rectus muscles contract markedly, and increase the intra-abdominal pressure to a considerable extent. For this reason, the last maneuver is highly recommendable.

SUMMARY

By exerting special effort and utilizing many of the positions and maneuvers suggested by several authors 35 or 2.3 per cent of 1,500 consecutive gastrointestinal examinations revealed a hiatus hernia. Ten were first seen while examining the patient in the erect position. Sixteen appeared in the supine position and 5 in the prone. Of the 4 remaining hernias, 1 was first seen after performing the Valsalva test and 3 after the "straight leg raising" maneuver. The Trendelenburg position and the cough maneuver failed to demonstrate a single hernia not previously seen. In addition to the 3 patients in which the straight leg raising demonstrated a previously unfilled hernia there were 4 cases in which the maneuver enlarged an already filled hernia.

The percentage of hiatus hernias found in this series of patients is no higher than the percentages reported by others who were not diligently searching or using special methods and procedures to demonstrate them. The observations made during this study and an analysis of the mechanics of the methods suggested by previous writers lead one to suspect that the most important factor in demonstrating roentgenologically a hiatus hernia is to increase the intra-abdominal pressure. This in some instances can be accomplished by merely taking advantage of a protruding abdomen when placing the patient in the prone position or by exerting manual pressure in the supine position. It can also be produced by strain although such a procedure may not be advisable merely to demonstrate a hernia when the same effect can be obtained without straining. Numerous hiatus hernias, like other hernias, are often transient as in one of our series when it was demonstrated as only delayed filling on the six hour film (Fig. 7). Because of their transient nature some hiatus hernias can be shown only by resorting to unusual effort. Therefore, it must be kept in mind, when evaluating the findings of the examination and correlating them with the symptoms of the patient, that the presence of the hernia may be only an incidental finding and in the final analysis prove to be misleading information.

Fig. 7. A seventy year old male patient. The hernia was not demonstrated during fluoroscopic examination but is seen as a gas filled cardia above the diaphragm on six hour film with patient prone.

CONCLUSIONS

1. An incidence of 2.3 per cent was found in examining 1,500 consecutive patients for hiatus hernia.

2. Two-thirds of the hernias were found in women.

3. The average age of the patients having a hiatus hernia was sixty years.

4. Any procedure or maneuver which can be executed by the patient and which will increase intra-abdominal pressure is most likely to demonstrate a previously unfilled hernia.

5. A previously undescribed procedure, "the straight leg raising" maneuver is introduced as another suggested supple-

mentary procedure to demonstrate a hiatus hernia.

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SUBCOSTOSTERNAL DIAPHRAGMATIC HERNIA

WITH REPORT OF FIVE CASES

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SUBCOSTOSTERNAL diaphragmatic hernia is an essentially direct hernia containing a peritoneal sac which passes through a defect in the anteromedial portion of the diaphragm. Its synonyms are foramen of Morgagni hernia, also retrosternal, parasternal, substernal and anterior diaphragmatic hernia. It is considered by Harrington[7] to be on an embryologic basis, whether congenital or acquired, and comprises 2.7 per cent of all operated diaphragmatic hernias in his series of cases. Although over 100 cases have been reported in the literature, most are not definitely proved or are poorly documented. Saltzstein, Linkner, and Scheinberg,[10] in a recent review of the literature, found only 44 cases which they considered to be proved, and added 1 case of their own. Harrington's[7] series contains 10 additional cases, and Ritvo and Peterson[8] reported 2 cases adequately proved by roentgen examination which were not included in the paper of Saltzstein and his co-workers. This is a report of 5 cases, proved roentgenologically or surgically.

The foramina of Morgagni or Larrey's spaces are small triangular areas, limited anteriorly by the sternum, medially by the sternal portion of the diaphragm, and laterally by the costal portion of the diaphragm in the region of its attachment to the seventh costal cartilage. The bases of these triangles are directed anteriorly and the apices posteriorly. The areas do not contain muscle, but are filled with loose areolar and connective tissue, and form congenitally weak areas through which herniation is possible. Occasionally, these two areas are fused in the midline with absence of the sternal attachment of the diaphragm. The great majority of subcostosternal hernias occur on the right side, presumably because the left space of Larrey is usually reinforced by the presence of pericardium. In a few of the reported cases, however, the hernias were on the left side, or were bilateral. They are in relationship superiorly with the parietal pleura and often the pericardium. Harrington[2,3,5,6,7] in his series of articles on diaphragmatic hernias has discussed in great detail the embryology and anatomy of subcostosternal hernias. In most cases, the patients were over forty-five years old. It is said that obesity, and increasing abdominal pressure acting on a congenitally thin area in the diaphragm, predisposes to the formation of subcostosternal hernias. In the cases reported by Saltzstein[10] and co-workers, Harrington,[7] and Ritvo and Peterson,[8] 3 of the hernias (in children or infants) contained liver only, 7 omentum only, 17 colon only, 13 colon and omentum, 1 colon and liver, 1 small bowel only, 2 colon and small bowel, 10 colon and stomach, 1 stomach only, 1 stomach and omentum, and 1 was empty.

ROENTGEN FINDINGS

On roentgen examination, subcostosternal hernias are manifest by a varying sized, rounded density in the right, or rarely the left, anterior cardiophrenic angle. This density is usually fairly well circumscribed. Occasionally, the pleura may be seen reflecting from the mass to the chest wall indicating its extra pleural location. If the hernia contains a hollow viscus, shadows representing gas may be seen, although this is not always a reliable sign, as the loop of bowel at times may contain only fluid. All suspected cases should undergo examinations of the colon and stomach with barium. With barium enema, a loop of colon may be found to be within the hernia, or perhaps only a segment of the colon may be displaced upward toward the

hernia, depending on the degree of traction exerted by herniated omentum. If these examinations reveal no abnormality, the establishment of the diagnosis becomes more difficult. Pneumoperitoneum may be used to distinguish the hernia from a subdiaphragmatic mass, as the air will often fill the sac when the patient is upright. Pneumothorax would show the hernia to be extrapulmonary. Fluoroscopically, the paradoxical movement of the diaphragm occurring in eventration of the diaphragm may serve to distinguish it from subcostosternal hernia, which descends with the diaphragm, is non-pulsatile and cannot be separated from the right border of the heart. The differentiation from a mediastinal tumor in this area may be difficult or impossible. The hernia may simulate fluid in the pleural space; pleural thickening; lung, pleural or mediastinal tumor; pericardial celomic, or bronchial cyst.

The accurate diagnosis of these hernias is very important, both in distinguishing them from other lesions and in detecting the presence or absence of a hollow viscus. Rogers and Leigh[9] have covered the methods of differentiating right cardiophrenic angle masses in their excellent paper, and suggest a number of procedures, some or all of which may be necessary. Harrington[4] stresses the importance of routine examination of the gastrointestinal tract because of the very real possibility of incarceration, strangulation, or obstruction. In addition, if large enough, the hernia may cause varying degrees of compression of the lung. If compression of the lung or kinking of a bronchus is present over some period of time, the possibility of a chronic suppurative process being produced in the affected segment of the lung or lobe is worthy of consideration. Postoperative follow-up roentgenograms should be made and bronchography performed if indicated. In Colmers'[1] case, the right middle lobe of the lung was completely atelectatic, and its bronchus was kinked upward with collapse of the lumen distal to the kink.

REPORT OF CASES

CASE I. Mrs. J. McM. This sixty-one year old white married woman was admitted to Providence Hospital on April 14, 1949, for roentgenologic examination of the chest. She was referred by a mobile chest survey roentgen-ray unit which had reported an abnormality in her chest. For several years she had occasional distress in the right upper quadrant after eating fried and fatty foods, but no cramping or constipation. Several months previous to admission she had had a short period of a feeling of tightness in her right anterior chest which she had attributed to a cold, and which disappeared after a few days and did not recur. She had no other respiratory or abdominal symptoms. On physical examination the chest findings were negative. There was moderate tenderness to deep pressure in the right upper quadrant. There were no masses in the abdomen. Laboratory findings were non-contributory. Electrocardiograms revealed no abnormality. Roentgenograms of the chest showed a rounded, well circumscribed mass in the right cardiophrenic angle, anteriorly, measuring about 8 cm. in diameter (Fig. 1). There was no evidence of shadows of gas within the mass. No further roentgenologic studies were done.

On March 16, 1949, a right thoracotomy was performed. A subcostosternal hernia was found, and the hernial sac was opened, and found to contain only omentum. The hernia could be reduced through the diaphragmatic defect. The defect was repaired, and the patient had relatively uneventful postoperative course.

CASE II. Mrs. E. W. This fifty-eight year old white widowed woman was admitted to Providence Hospital on August 13, 1951, because of a mass in the chest found on a routine roentgenogram done by a mobile roentgen-ray unit. The patient had had occasional mild constipation for many years, which had not changed. During the six years previous to admission, she had had occasional mild sensations of pressure and fullness in the right posterior chest. When this began, she consulted an orthopedist because she thought the pain was originating from her back. She stated that he took roentgenograms of her spine and told her that there were no positive findings. Roentgenograms of the chest were not taken. She had had no other significant chest or

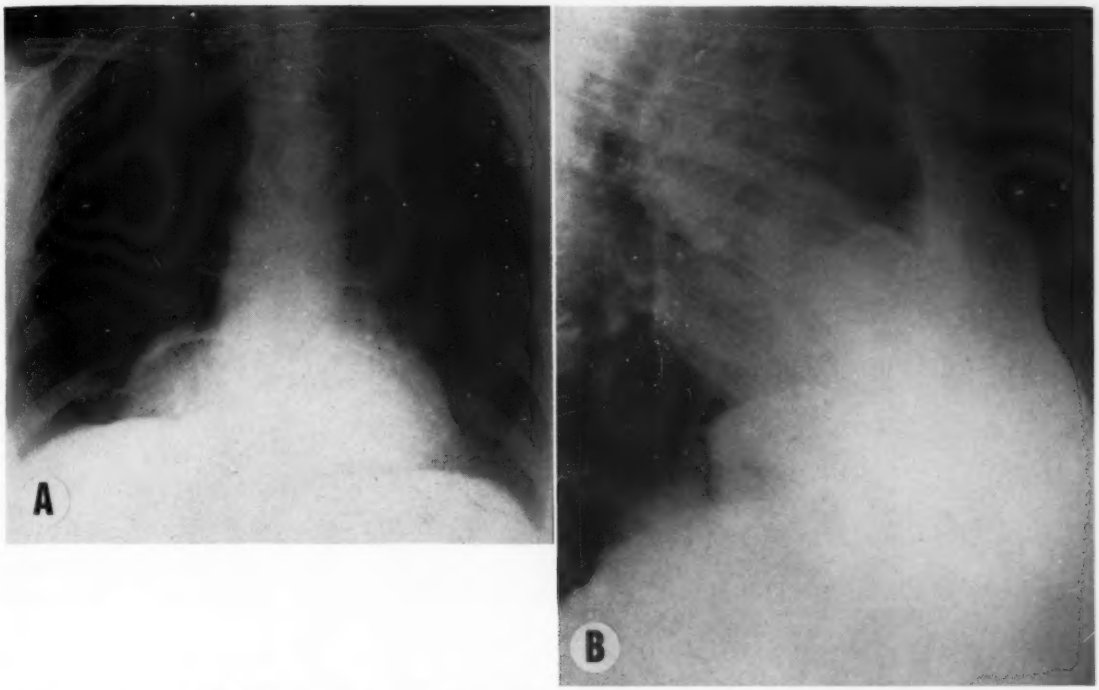

Fig. 1. Case 1. (*A*) Posteroanterior film showing rounded dense mass in the right cardiophrenic angle. (*B*) Lateral film of same case.

abdominal symptoms. Findings at physical examination and in the laboratory were non-contributory. Electrocardiograms revealed no chest abnormality. On August 15, 1951, roentgenograms of the chest showed a rounded density in the anterior chest, medially, measuring 8 cm. in diameter, and containing a bubble of gas overlying fluid. There were a few linear atelectatic streaks in the lungs just above the mass (Fig. 2*A* and *B*). The impression was that a subcostosternal hernia was present containing a segment of the gastrointestinal tract. A colon examination was performed and a loop of right transverse colon, and probably hepatic, flexure, was found to be included in the hernia (Fig. 2*C*). There was moderate constriction of the colon where it passed through the diaphragm. Fluoroscopy of the chest showed a non-pulsatile mass which moved with the diaphragm. Examination of the stomach revealed no abnormality. The patient was then discharged as she wished to take care of personal affairs. She was re-admitted on August 25, 1951, and on August 27, 1951, a right thoracotomy was performed. An orange-sized mass, protruding through a defect 3 cm. in diameter in the diaphragm, was found. The incision was carried into the right rectus region of the abdomen. The loop of colon and omental tissue were freed manually through the abdominal incision and replaced in the abdomen. The hernial sac was then resected and the defect in the diaphragm repaired. The patient's postoperative course was uneventful.

Case III. Mrs. R. W. W. This sixty year old white married woman was admitted to Providence Hospital on August 20, 1951, because of pain in the chest. In July, 1950, she developed the first of several attacks of pain on exertion in the right anterior chest, which radiated through to the back and to the tip of the right shoulder. These attacks lasted a day or two at a time. Roentgenologic examinations of the gallbladder, stomach and colon were performed elsewhere and were reported to have revealed no abnormality. No information could be obtained as to whether fluoroscopy of the chest was performed. She had had no abdominal pain, constipation, or other symptoms. Findings at physical examination and in the laboratory were non-contributory. Electrocardiograms showed no significant abnormalities. Routine roentgenograms of the chest

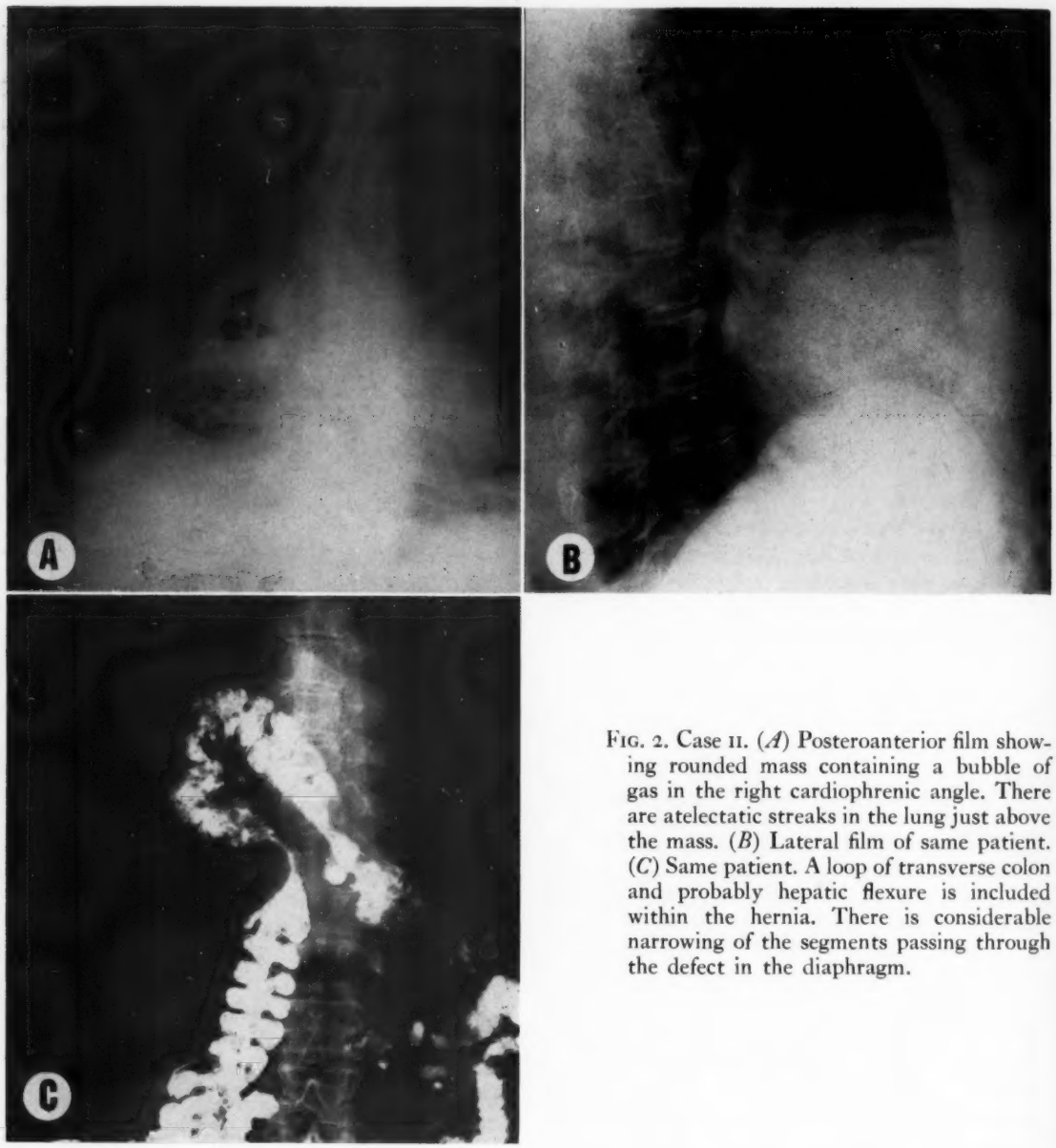

Fig. 2. Case 11. (*A*) Posteroanterior film showing rounded mass containing a bubble of gas in the right cardiophrenic angle. There are atelectatic streaks in the lung just above the mass. (*B*) Lateral film of same patient. (*C*) Same patient. A loop of transverse colon and probably hepatic flexure is included within the hernia. There is considerable narrowing of the segments passing through the defect in the diaphragm.

taken on admission showed a large, rounded, dense mass in the right cardiophrenic region anteriorly (Fig. 3*A*). No shadows of gas could be seen within the mass. On the lateral view the pleura could be seen reflecting off the mass onto the anterior chest wall and onto the right leaf of the diaphragm (Fig. 3*B*). A few atelectatic streaks were seen in the right middle lobe, which was posterior to and slightly above the mass. No further roentgenologic studies were done. On August 22, 1951, right lower thoracotomy was performed. A large hernia was found protruding through the foramen of Morgagni on the right side. The sac was opened and found to contain omentum only. The foramen of Morgagni defect measured 1 by 3 cm. in diameter and was too small to enable reduction of the contents of the hernia, so amputation of the hernial sac and its omental content was performed. The defect was repaired, and the patient's postoperative course was relatively smooth. The pathologist reported that

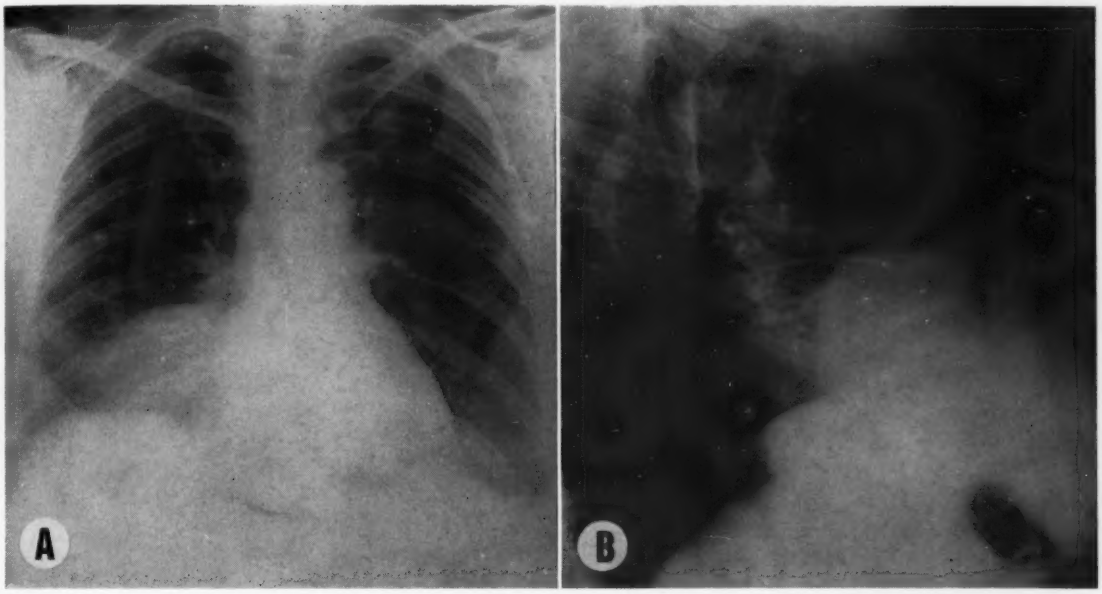

Fig. 3. Case III. (*A*) Posteroanterior film showing a large rounded mass in the right cardiophrenic angle. There are atelectatic streaks in the lung above the mass. (*B*) Same patient. Pleura is reflected from the anterior chest wall over the mass.

the gross material consisted of a hernial sac containing 150 grams of fatty tissue.

Case IV. Mrs. W. F. J. This sixty-seven year old white married woman was admitted to Providence Hospital because of discovery of a mass in the chest on routine roentgenograms of the chest. Several months previous to admission, the patient had had numerous attacks of generalized abdominal pain following ingestion of fatty or fried foods. Roentgenologic examination of the abdomen prior to admission showed multiple, partially calcified, gallstones in the right upper quadrant. She denied any further abdominal symptoms or constipation, and had had no respiratory difficulties or pain in the chest. Findings at physical examination and laboratory procedures were non-contributory. Roentgenograms of the chest showed a large rounded mass in the right cardiophrenic region, anteriorly, measuring approximately 10 cm. in diameter (Fig. 4*A*). There were no shadows of gas present. On the lateral view the pleura could be seen reflecting from the mass onto the anterior chest wall (Fig. 4*B*). There was no evidence of compression of lung. No further roentgenologic procedures were carried out.

On August 16, 1951, a right lower thoracotomy was performed. There was a large hernia protruding through the foramen of Morgagni which when opened contained only omentum. It was impossible to reduce the contents of the hernial sac, so the sac, including its omental content, was resected and the diaphragmatic defect was repaired. The pathologist reported that the material consisted grossly of a hernial sac containing 150 grams of fat. The patient's postoperative course was uneventful.

Case V. Mrs. N. W. This sixty-one year old white widowed woman was first admitted to Firland Tuberculosis Sanatorium on August 17, 1949, because tubercle bacilli were found in her sputum. She had had two previous hospitalizations for active tuberculosis in 1928 and 1938 at sanataria outside of this city. Her complaints on admission consisted of occasional mild epigastric discomfort without apparent relation to meals, and of long standing frequent attacks of substernal pressing pain radiating to the left shoulder and down the left arm. The onset of these attacks would occur sometime after midnight while the patient was in bed, and would disappear when she sat up or stood for about one half hour. She had had a chronic, non-productive cough for many years. There were no complaints referable to the gastrointestinal tract. Physical findings on admission were not remarkable except for a

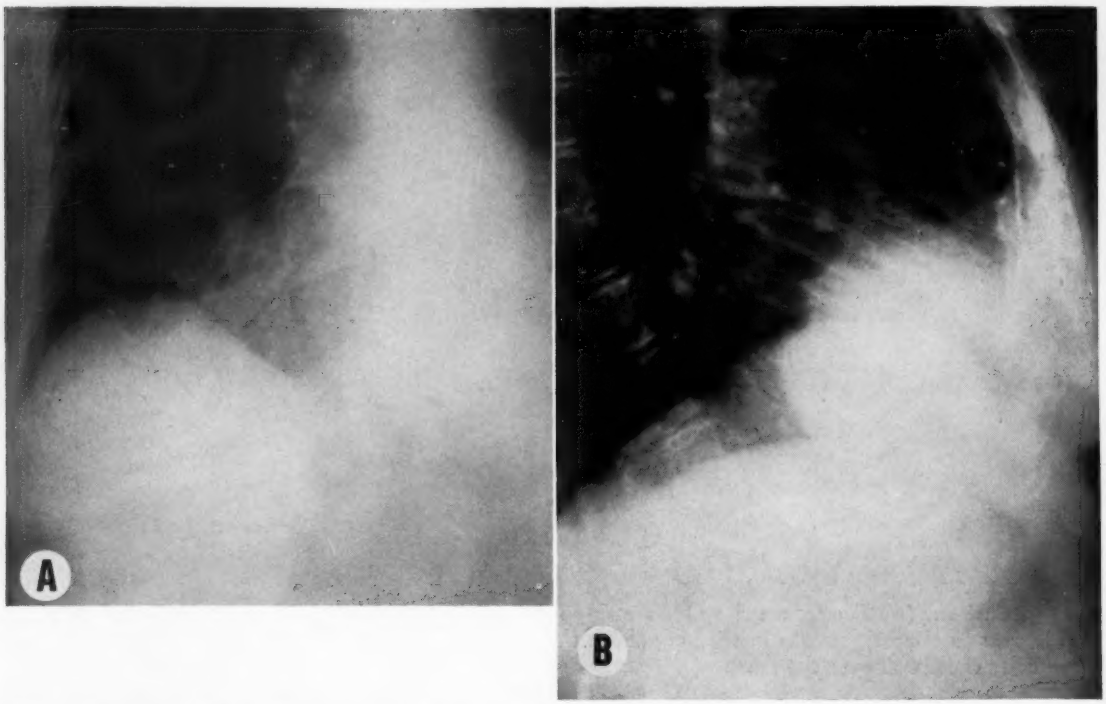

FIG. 4. Case IV. (*A*) Posteroanterior film showing a large rounded mass in the right cardiophrenic angle. (*B*) Same patient. Lateral view shows the reflexion of pleura from the anterior chest wall over the mass.

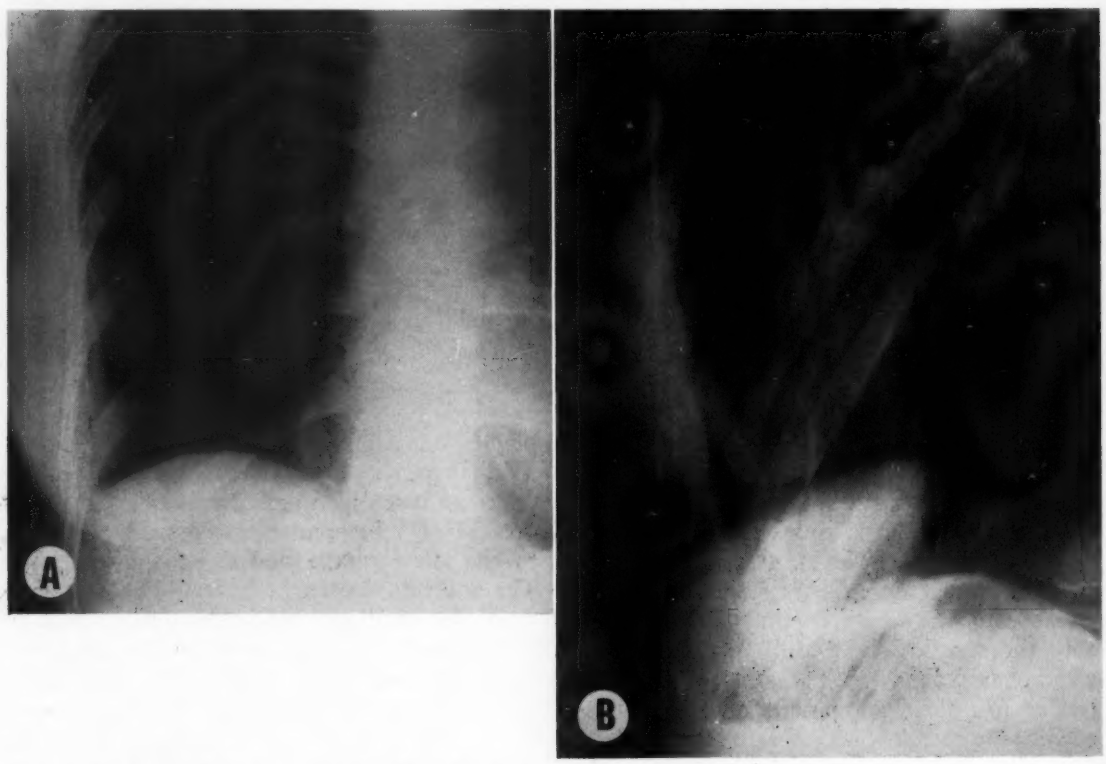

FIG. 5. Case V. (*A*) Posteroanterior film showing a very small rounded mass in the right cardiophrenic angle. (*B*) Lateral film shows the mass to be anterior. It is almost obscured by the dome of the right hemidiaphragm.

blood pressure of 185/95. Electrocardiograms and Master's two-step test revealed no abnormalities. Routine roentgenograms of the chest revealed the presence of moderately advanced active tuberculous lesions in the right upper lobe, and an oval mass in the right cardiophrenic angle, anteriorly, measuring 6 by 4 cm. in diameter (Fig. 5). The impression was that this was a subcostosternal hernia. Fluoroscopy of the chest was non-contributory, because the mass could not be well visualized. Examination of the stomach revealed no abnormalities. Roentgenograms of the chest taken occasionally since 1947 up to the time of admission showed no evidence of the mass.

During her sanatorium stay roentgenograms of the chest were taken every three months. These showed no change in the mass or in the tuberculous process in the right upper lobe. The sputum continued to contain tubercle bacilli so a right upper lobectomy was performed on January 21, 1952. After the right thorax was opened and the right upper lobe removed, the lower chest was inspected. The surgeon's report states, "Down near the cardiophrenic angle, anteriorly, was an 8 cm. mass of yellow tissue, grossly resembling fat. On palpation it was soft and had the consistency of omentum. One could insert his finger through a small opening of the diaphragm, and the impression was that the mass was an omental hernia through the sinus of Morgagni. It was decided to leave this alone." Finally, thoracoplasty was performed on the right side.

The patient's postsurgical course has been uneventful. She has had no further attacks of substernal pain radiating to the left shoulder. Postoperative roentgenograms of the chest showed no change in the subcostosternal hernia.

DISCUSSION

The relative paucity of reported cases of subcostosternal hernia probably does not reflect their true incidence. They are undoubtedly recognized by most radiologists when encountered, but their importance may not be appreciated, particularly if they seem to contain only omentum, and additional definitive examinations are often not done. Of all the cases reported, 77 per cent contained various segments of the gastrointestinal tract, and certainly the possibility of incarceration, strangulation, or obstruction must be considered. Colmers,[1] in quoting European authors, states that these complications occurred in 10–15 per cent of all cases. Harrington[5] recommends immediate operative correction of all subcostosternal hernias containing stomach or bowel, and, at the least, careful watching of those hernias containing only omentum at the time of examination, since they are potential receivers of segments of the gastrointestinal tract. In any case of suspected subcostosternal hernia, a complete roentgenologic examination of the gastrointestinal tract should be performed in order to determine what the contents are, if the mass is a hernia. If dyspnea or other respiratory symptoms are present, roentgenologic studies of the chest should be made to determine the degree of compression of adjacent lung, and to exclude the possibility of kinking of a bronchus with resultant bronchial obstruction. As previously mentioned, chronic pulmonary suppurative disease may follow prolonged compression or bronchial obstruction.

In this series all 5 hernias contained omentum. In 1 patient the hernia contained a loop of colon, but the patient had had no symptoms which could be attributed to obstruction of the herniated colon. Three patients had varying degrees of pain or sensations of pressure in the right chest, but no dyspnea or other respiratory difficulty. The roentgenograms of 2 of these patients showed linear atelectasis in the region of the right middle lobe, most probably due to compression. The third patient had substernal anginal-type pain occurring when lying down. Following right upper lobectomy for localized tuberculosis, the substernal pain was relieved and has not recurred. The hernia, however, was not corrected surgically. Two of these patients had no symptoms which could be attributed definitely to the hernia, but neither hernia was found to contain any segment of the gastrointestinal tract, or to have any apparent compression of the lung or bronchial obstruction.

SUMMARY

1. The anatomic and roentgenologic features of subcostosternal hernia are presented, and a brief review of cases previously reported in the literature is given.

2. Five new cases of surgically proved subcostosternal hernias are described.

3. The importance of doing complete gastrointestinal examinations on suspected subcostosternal hernias is stressed. Additional roentgenologic studies of the chest may be necessary to prove the extrapleural nature of the hernial mass if no gastrointestinal abnormalities are found.

4. Radiologists should be fully aware of potential danger of incarceration, obstruction, and strangulation of segments of the gastrointestinal tract included within a subcostosternal hernia.

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PHYSIOLOGIC CONSIDERATIONS IN THE PROBLEM OF PEPTIC ULCER*

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PERHAPS it may be permissible to introduce a discussion of certain physiologic aspects of peptic ulcer with a brief consideration of the pathogenesis of the lesion. Radiologists, by the very nature of the method used by them, are inclined to think first in terms of gross pathology. Perhaps this is one of the reasons why the old concept of peptic ulcer as a process due to vascular thrombosis with subsequent infarction and digestion of the slough was readily accepted. Nearly all radiologists have seen large gastric and duodenal ulcers decrease in size and heal; many radiologists contend they have never seen an ulcer *increase* in size. It seems to us, however, that the total evidence available, clinical, roentgenologic and experimental, contradicts the concept of infarction and proves that peptic ulcer is a penetrative, invasive process.

The very life history of peptic ulcer, characterized as it is by episodes of massive hemorrhage or of acute perforation occurring in a chronic ulcer, indicates penetration and extension. Perhaps the best experimentally produced ulcers are the eroding, penetrating gastric or jejunal lesions occurring after the so-called Mann-Williamson[5] operation. Equally instructive are the ulcers obtained in animals of various species with the subcutaneous injection of histamine-beeswax (Wangensteen[13]) producing a continuous hypersecretion of highly acid gastric juice and penetrating ulcers with the usual complications of massive hemorrhage and acute perforation. Roentgenologic evidence of penetration of human ulcers has been obtained although it has not been universally accepted. It is interesting to note that in Berg's[2] first edition published in 1930, there is pictured a large gastric ulcer which, one and one-half years later, had deepened markedly. Eight days after the last film was taken the ulcer perforated into the peritoneal cavity, as was proved at operation and by the death of the patient. More recent evidence of such a process is to be found in Meuwissen's[6] atlas published in 1955 showing a gastric ulcer which recurred and increased in size at various times from 1939 to 1951. In the past thirty years we have repeatedly seen roentgenologically gastric, duodenal and jejunal ulcers increase in size and depth; similar increases in gastric ulcer have been observed gastroscopically.[7]

From the standpoint of etiology it is clear that peptic ulcers are indeed peptic ulcers; they are the result of the digestive action of the acid gastric juice. The old observation of Schwartz: "No acid—no ulcer" has proved to be correct. Chronic gastric and duodenal ulcer do not occur in complete absence of acid gastric secretion. Furthermore, if complete and permanent anacidity develops spontaneously or is produced therapeutically, the ulcers heal and remain healed for the duration of the achlorhydria. In a patient, followed most carefully by many roentgenologic and gastroscopic examinations from 1936 to 1946, the size of the ulcer as seen roentgenologically and gastroscopically waxed and waned, but the ulcer persisted. In 1946 a course of radiation therapy was given; this was followed, fortunately, by a complete anacidity persisting to the present time. The ulcer healed and has not recurred (Fig. 1).

While time does not permit a detailed discussion of the variations in gastric secretion in patients with ulcer, it may suffice to point out that the average fasting secretion in patients with duodenal ulcer is

* From the Frank Billings Medical Clinic, Department of Medicine, University of Chicago, Chicago, Illinois. Presented before the Fifty-sixth Annual Meeting, American Roentgen Ray Society, Chicago, Illinois, September 20–23, 1955.

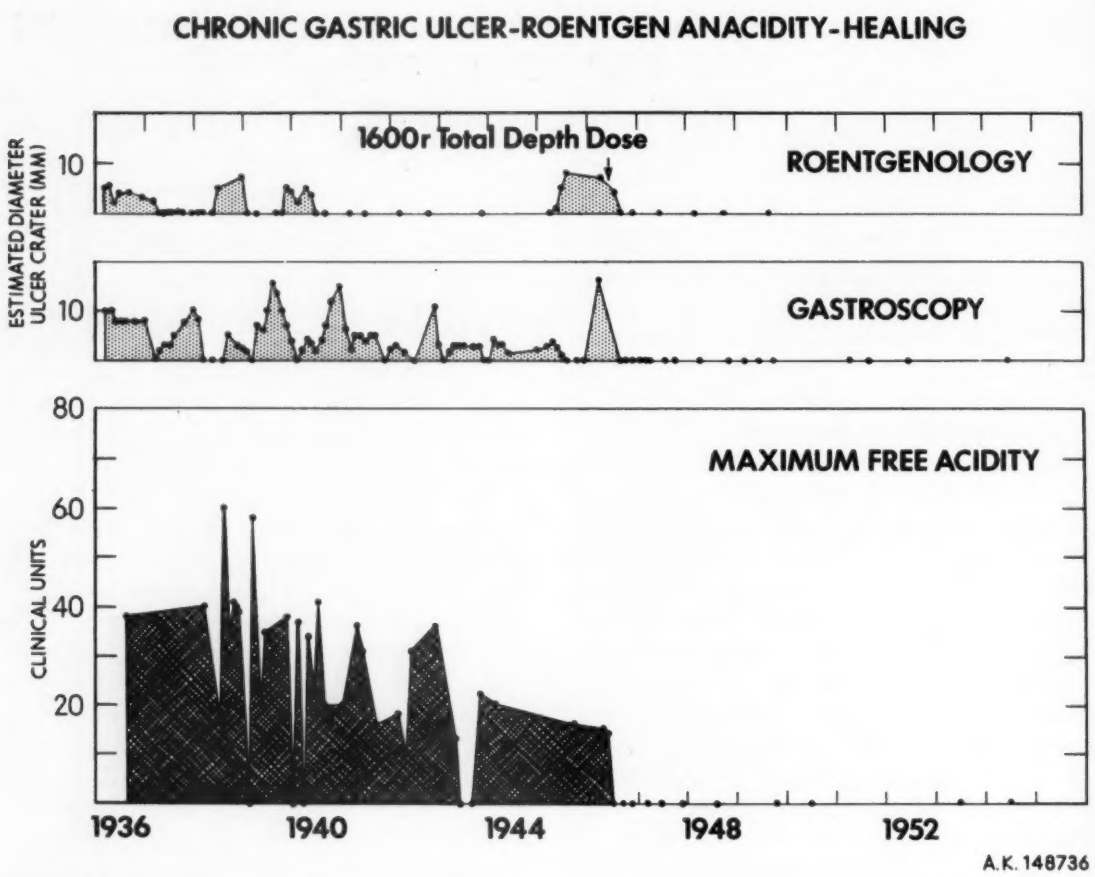

FIG. 1. (A.K. Unit No. 148736.) Graphic depiction of a chronic recurring gastric ulcer seen repeatedly at the same site by roentgenologic examination from 1936 to 1946, and seen at almost each examination gastroscopically during this period. Each dot represents an examination. The patient was subjected to over one hundred gastroscopic studies. The ulcer was seen to increase and decrease in size as illustrated by the chart, but it did not disappear completely and permanently until 1946, at which time a course of radiation therapy was administered, total depth dose 1,600 r. The lower line shows the maximum free acidity at each of the numerous gastric analyses (histamine). It will be noted that complete histamine achlorhydria developed following the radiation therapy and has persisted to date (1955).

almost four times as great as that in normal individuals, whereas in patients with gastric ulcer the fasting secretion averages less than normal (Table 1). An important point to make in connection with gastric

TABLE I

FASTING NOCTURNAL SECRETION (12 HR.)

	Normal	Duodenal Ulcer	Gastric Ulcer
Total Free HCl. (mg.)	661	2242	454

TABLE II

CHRONIC RECURRENT PEPTIC ULCER
(5 male patients)
Very Excessive Nocturnal Gastric Secretion

	Output HCl. (mg.)
A. Average Normal	661
B. Average Duodenal Ulcer	2242
C. Average Present Group	Case: 1. 3820 2. 3795 3. 2940 4. 3987 5. 5507

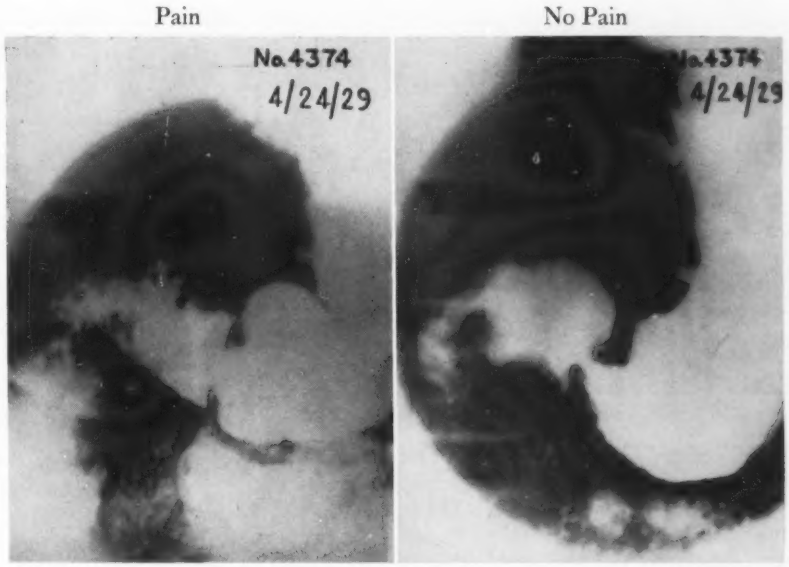

Fig. 2. In the left hand view the barium filled stomach of the patient with a benign ulcer on the lesser curvature is shown during the presence of pain induced by the administration of barium suspended in an 0.5 per cent solution of hydrochloric acid. The right hand film was taken thirty minutes later, after the acid had been neutralized by means of an antacid. Attention is called particularly to the fact that during pain, as shown in the left hand view, there is no hyperperistalsis, the pylorus is open, and the duodenal bulb is well filled. Fluoroscopic study disclosed no significant difference in the behavior of the stomach during pain and in the absence of pain.

ulcer is that even though the secretion may be low as compared with normal, free acid is present in sufficient amounts to activate pepsin and thus to make possible peptic digestion. In duodenal and jejunal ulcer the problem of healing and recurrence is dominated by the excessive nocturnal acid secretion which may reach very high levels (Table II).

The problem of therapy relates to inhibition of secretion or neutralization of the acid secreted. Both are difficult because the stomach works day and night. There are no drugs, procedures or operations which afford ideal control.

Table III

Pain from Re-introduction of Gastric Content

Patient A.G. Active Duodenal Ulcer

Experiment 370

7:00	Ward breakfast
9:50	Typical pain appeared
10:10	Stomach emptied of 140 cc. of thin gruel. Free acidity, 37; total, 77
10:15	Pain entirely gone
10:22	120 cc. of gruel emptied at 10:10 re-introduced
10:40	Pain returned
10:54	250 cc. of cold eggnog
11:00	Pain entirely gone

Another physiologic problem is the mechanism of the pain. The observation that the viscera are insensitive to ordinary mechanical and chemical stimulations led to the conclusion that visceral pain arose only from changes in muscle tension. The observations of Bönninger[4] in 1908 were overlooked. Bönninger showed that ulcer pain could be induced under appropriate conditions by the introduction into the stomach of dilute solutions of hydrochloric acid. Sippy[12] observed that when pain attributable to ulcer was present the gastric contents were invariably highly acid and removal of the acid chyme relieved the pain. It was a simple step to re-introduce the acid gastric content and reproduce the pain[8] as shown in the following protocol (Table III). The introduction of gastric juice with no free acid did not evoke pain. A dilute solution of hydrochloric acid did

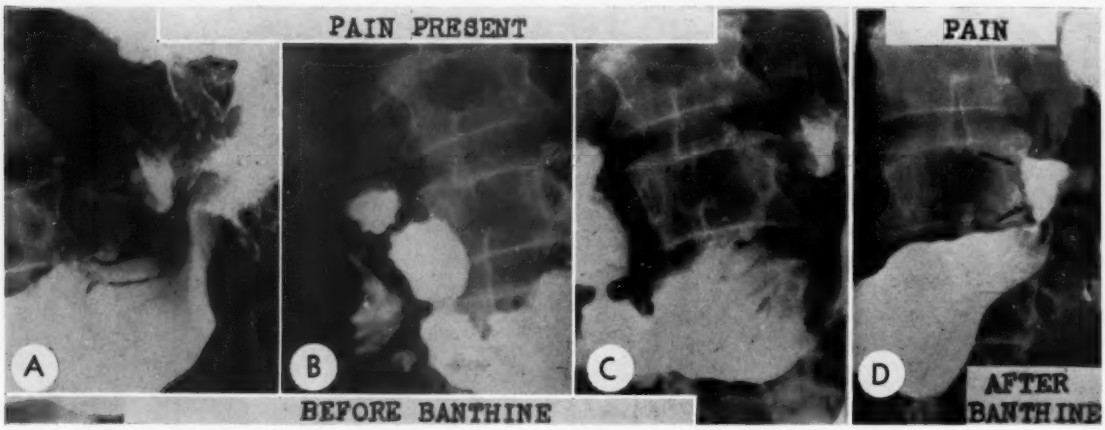

FIG. 3. The appearance of the stomach with gastric ulcer during pain before and after the administration of banthine, 50 mg., intramuscularly. The crater is clearly seen in views *A*, *C*, and *D*. Attention is called to the absence of abnormal motor activity. In views *B* and *C*, the antrum is only partially contracted, the pylorus is open, the duodenal bulb is well filled. Exposure *D*, taken after banthine but during pain, discloses no significant difference.

do so as shown in the following protocol (Table IV).

These experiments have been repeated hundreds of times under appropriate conditions. The disagreements between investigators have revolved about the manner in which acid produces pain. Does it do so by direct irritation of the nerve endings in the base of the ulcer or by inducing hyperperistalsis, spasm or abnormal motility? Kymographic studies made thirty years ago with the balloon in the stomach or duodenum showed that ulcer pain was not accompanied by any increase in intragastric tension, altered motility or spasm. These studies were confirmed in detail in 1946 by Bonney and Pickering[3] and more recently by other workers.[11,16]

Roentgenologic studies[9] in 1926, repeated subsequently, indicated no significant difference in the behavior of the stomach with or without pain (Fig. 2). There was no evidence of pylorospasm or other abnormal motility. More recent similar studies before and after Banthine and other anticholinergic drugs have corroborated this conclusion (Fig. 3).[10] The evidence indicates that pain may be produced and, indeed, usually is produced by direct acid irritation of the nerve endings. The question arises as to how this can be true if the stomach and intestine are really insensitive to mechanical and chemical stimulation. The problem thus centers on visceral sensibility and visceral pain thresholds.

Whitlow[14] indicated many years ago that inflammation does lower the visceral pain threshold. Bentley[1] noted that "the exposed ulcerated stomach or duodenum was sensitive to pressure, to pinprick and to chemical stimulation. The non-ulcerated stomach wall was insensitive to stimuli." Wolf and Wolff[15] applied mustard to an area of gastric mucosa, keeping another area as a control, and from time to time subjected the two areas to stimulation. When the mustard treated side was "intensely red, boggy and edematous—intense pain occurred with the application of the stimuli" whereas no pain occurred when the stimuli were applied to the control area.

TABLE IV

PRODUCTION OF ULCER PAIN BY HCl.
Patient E.B. Active Duodenal Ulcer

8:45	Stomach emptied, 40 cc. Free HCl. 0
8:50	200 cc. 0.5 per cent HCl.
9:05	Typical distress appears
9:20	Stomach emptied, 215 cc. Free HCl. 110. Pain relieved immediately

These observations suggest that the numerous vague and indefinite, although time honored theories of visceral pain must be discarded. Visceral nerves differ from parietal nerves in that they have higher pain thresholds, perhaps react to different forms of stimuli and produce sensations less readily localized, but nevertheless visceral nerves do convey pain impulses to the higher centers.

The evidence available indicates that in peptic ulcer the pain threshold is lowered, presumably by the chemical inflammation, and that previously painless stimuli, mechanical and chemical, then become painful. Thus acid gastric juice becomes the agent responsible for the chemical inflammation and the lowered pain threshold; it is the usual stimulus for the production of pain. Gastric and duodenal peristalsis and spasm may also evoke pain when the mechanism is sensitive. Protection of the ulcer from the acid attack is followed by rapid desensitization of the ulcer; the pain threshold rises; the lesion becomes insensitive to both chemical and mechanical stimuli, and in time the ulcer heals.

CONCLUSION

Peptic ulcer is an invasive, penetrative process, a disease of abnormal physiology. Acid gastric juice is responsible wholly or in part for the ulcer, for its chronicity, for the inflammation present, for the lowered pain threshold and for the production of pain.

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THE ANATOMICAL BASIS FOR THE EPSILON SIGN OF FROSTBERG

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A STRIKING double scallop of the concavity of the periampullary segment of the second portion of the duodenum has been variously referred to as "the inverted figure 3 sign," "Frostberg's sign" or, more succinctly, the "epsilon (ϵ) sign." It is widely held (Frostberg,[5] Templeton,[10] and Buckstein[3]) that this configuration is to be attributed to neoplasm of the ampulla or papilla of Vater, or to enlargement of the head of the pancreas.[4] Recent experience with a number of patients presenting this characteristic configuration, forces one to the conclusion that such concepts can lead to serious error.

The evidence against these and similar conclusions is not apparent until one closely examines the detailed morphology. In the first place, the size of the ϵ deformity under discussion must be roughly fixed. A study of the cases on record indicates that this is of the utmost importance. Of Frostberg's three cases, Cases 2 and 3 were large ϵ's occupying most of the sweep of the second portion of the duodenum. His Case 1, which has served as the pattern for subsequent studies, is complicated by a second huge filling defect superimposed upon the ϵ configuration. These cases were all fatal and associated with enlarged liver, icterus and blood in the stools. In contrast, Feldman's[4] cases, showing a configuration similar to Frostberg's Case 1, were apparently quite benign in nature and not associated with jaundice, impaired gallbladder function or stone, although 3 did have occult blood in the stools. None is reported as having been fatal and, unfortunately, no follow-up studies are recorded.

Combining the 2 groups of cases has caused some confusion, as a result of which Frostberg shares with von Recklinghausen the distinction of having narrowly escaped failing to describe the condition which bears his name.

Many cases described under this heading do not actually present an epsilon sign, but are merely bizarre deformities of the second portion of the duodenum which only vaguely approximate it. Moreover, very small ϵ configurations can be observed on both the concavity and the convexity of the duodenum due to large folds seen in profile.

It is thus evident that several different categories of cases are under discussion, unless this is restricted to the moderate sized ϵ's of Feldman's series or Frostberg's Case 1. In this report, only the latter types of ϵ's are under consideration.

In analyzing this configuration, attention must be paid to various opinions as to the origin of the limbs of the ϵ. Teschendorf,[11] who has attributed the "inverted 3 configuration" to enlargement of the pancreatic head, used this explanation to account for both the upper and lower indentations. It seems quite improbable, however, that a nodular enlargement of the pancreatic head would fortuitously occur in precisely this region in the frequency in which it is encountered. The fact that the lower loop of the ϵ is almost invariably longer than the upper, in published cases and in my own material, requires a more definite anatomical substrate than random nodularity of the pancreas. It is further improbable that the regression seen in my own cases would be so uniform and so complete with pancreatitis. Finally, enlargement of the pancreatic head actually over-explains the configuration as it incorrectly identifies the cause of the lower indentation with pancreatic disease *per se*, whereas it can be proved to be due to enlargement of the major papilla.

Commenting on Frostberg's Cases 1 and 2, Templeton[10] states, "It seems likely that in this and the previous case, the indenta-

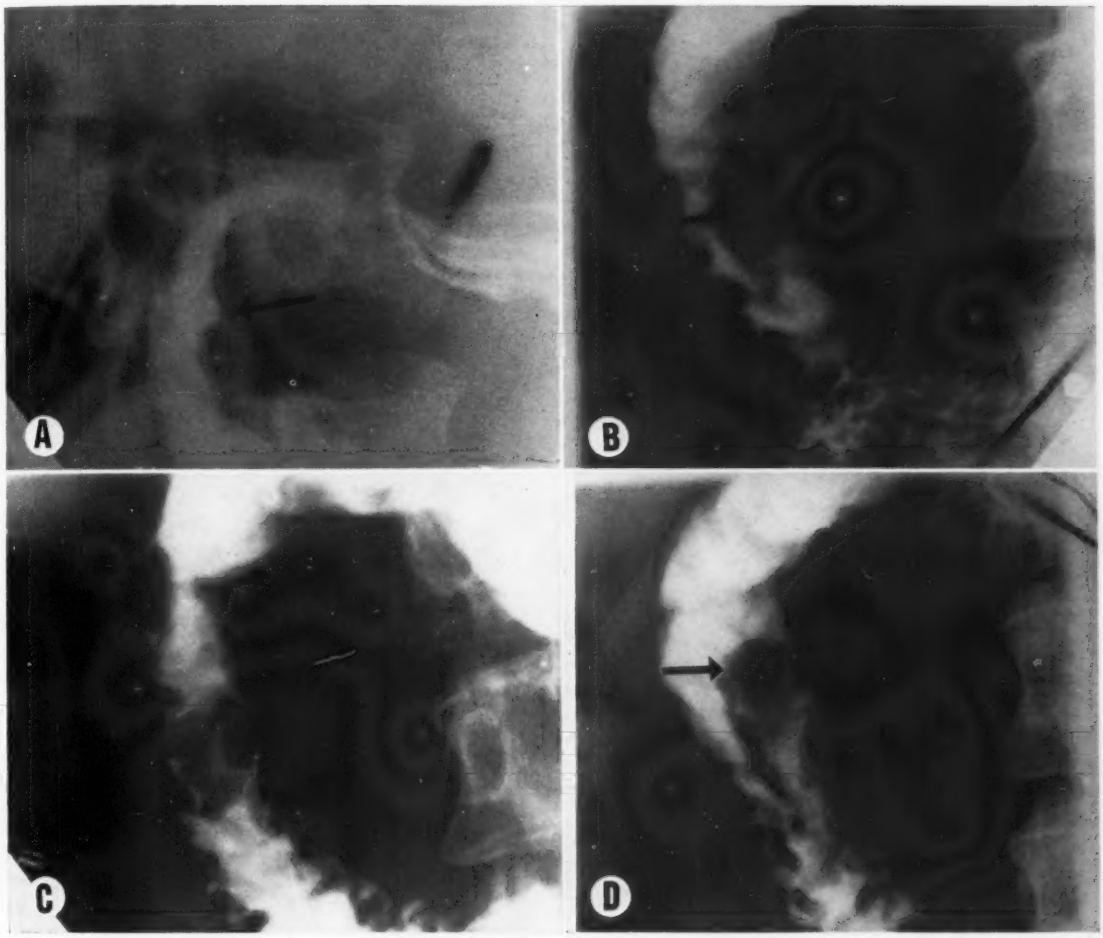

Fig. 1. Case 1. (*A*) The epsilon configuration of the second portion of the duodenum. The lower limb of the epsilon is more sharply defined. (*B*) Right anterior oblique projection with compression. The lower limb of the epsilon is now seen *en face* as a 2 by 1.5 cm. filling defect. Note that the small collection of barium forming the point of inflexion of the epsilon is still visible and is not centrally situated with respect to the filling defect. Note the second small, partially obscured, polypoid filling defect just above the main elevation and also observe its relationship to the stem of the "ϵ." (*C*) In the same projection, with slightly less compression, the plica about the opening of the ampulla are seen to be centrally situated with respect to the filling defect, positively identifying it as the papilla of Vater. (*D*) By varying the obliquity slightly and critically adjusting the amount of compression, the small filling defect seen in *B* is shown to better advantage. It is situated above the stem of the epsilon and forms its upper arch. It can thus be identified as the minor papilla. Note its relationship to the major papilla which is seen in profile below the stem in this projection. This patient was a twenty-eight year old athlete whose complaints of gnawing epigastric pain were completely relieved by a peptic ulcer regimen. Re-examination in four weeks showed complete regression of the findings described above. A recurrence of symptoms a few months later was associated with mild enlargement of the major papilla which again regressed with treatment.

tions described at roentgen examination were caused by bulging of the lips of the papilla of Vater into the duodenum."

My own material excludes such an interpretation. As shown in Figure 1, the lower loop of the ϵ can be demonstrated to be an enlarged major papilla by rotating the patient through an angle of about 45° when the spot films show the classical appearance of an enlarged major papilla. This at once throws out speculation that the entire configuration may be due to enlargement of the

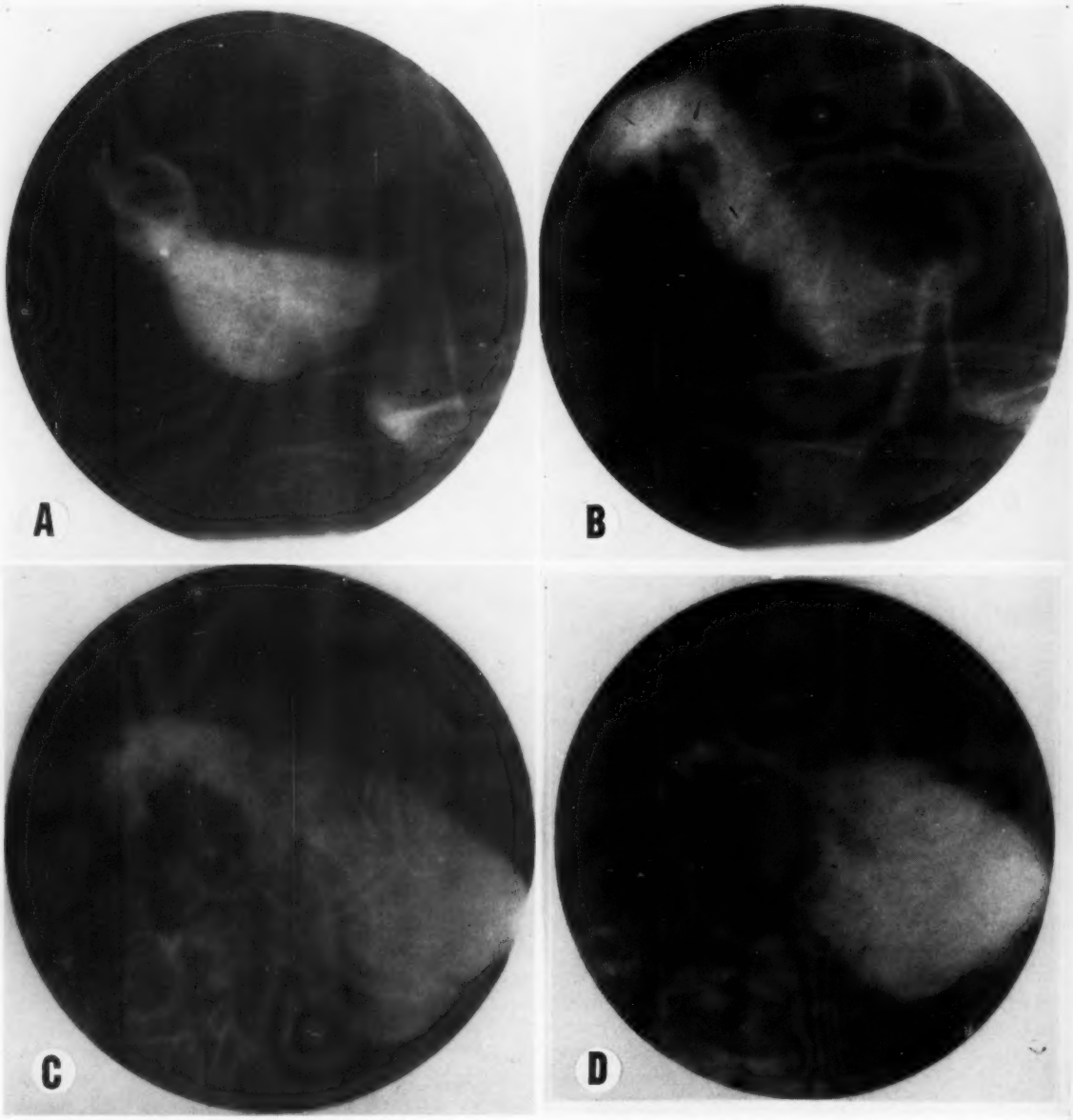

FIG. 2. Case II. (*A*) With initial, partial filling of the bulb, a regular filling defect appears at the genu. (*B*) With filling of the region of the genu, the filling defect is seen to be situated on the concavity. It measures about 13 mm. in diameter on the films. Short radiating folds about a central oblique umbilication form a rosette configuration. (*C*) Right anterior oblique projection with compression. The filling defect enlarges as it is spread out by the compression. The margins now appear scalloped around the entire circumference. The mucosal folds covering the papilla account for the scalloping. (*D*) With more forceful compression the margins appear smooth, and there is a further increase in the diameter of the filling defect.

major papilla with the lips of the papilla, as seen in cross section, forming an ϵ configuration. It is also apparent that the small, sharp pocket of barium between the two indentations of the concavity of the second portion is not due to reflux of barium into the common duct.

The third crucial point is the precise explanation for this small pocket of barium which projects between the upper and lower limbs of the epsilon. Feldman, following the suggestion of Frostberg, concluded that the central tongue of barium represented the "papilla." Teschendorf in-

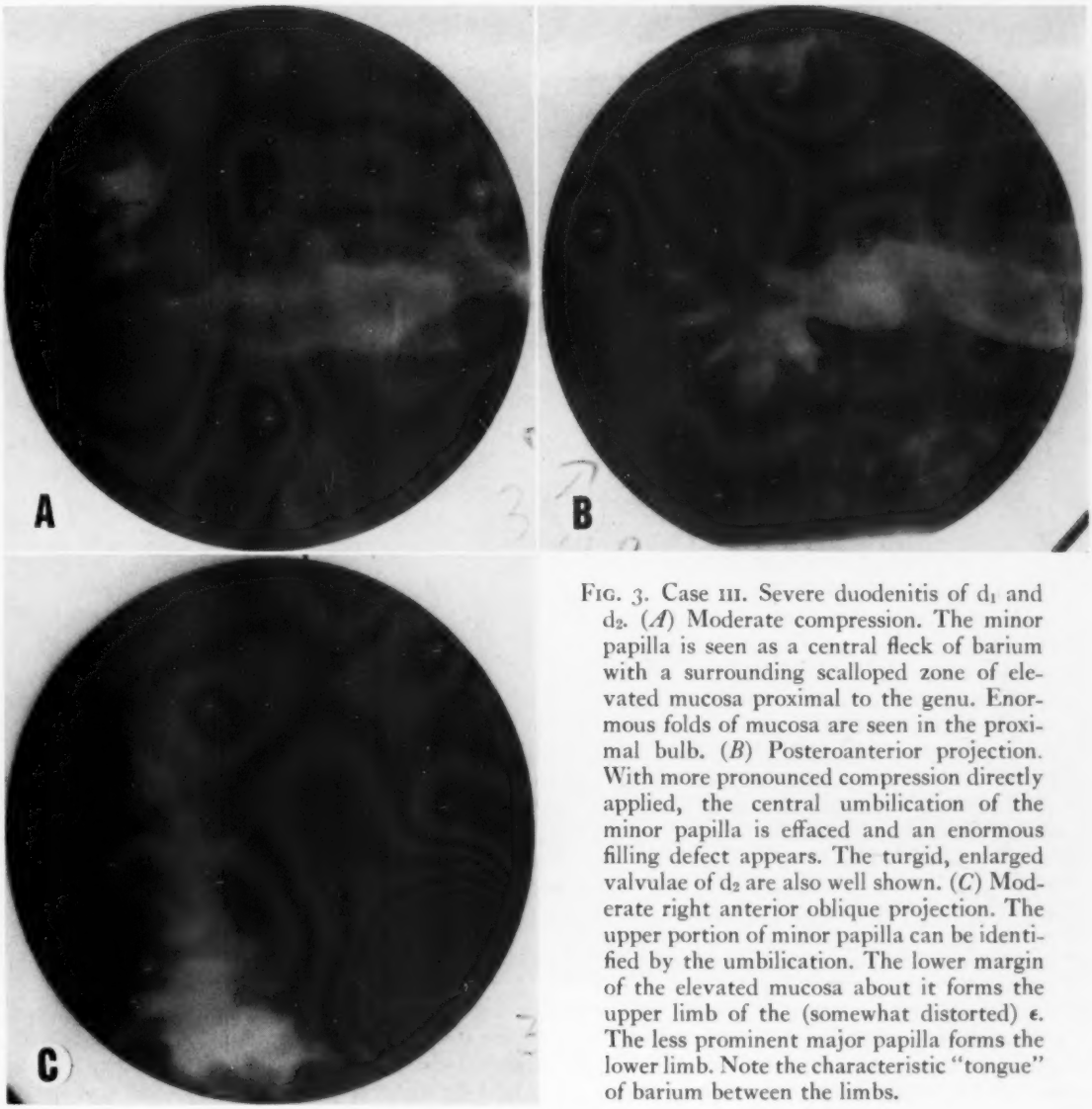

Fig. 3. Case III. Severe duodenitis of d_1 and d_2. (*A*) Moderate compression. The minor papilla is seen as a central fleck of barium with a surrounding scalloped zone of elevated mucosa proximal to the genu. Enormous folds of mucosa are seen in the proximal bulb. (*B*) Posteroanterior projection. With more pronounced compression directly applied, the central umbilication of the minor papilla is effaced and an enormous filling defect appears. The turgid, enlarged valvulae of d_2 are also well shown. (*C*) Moderate right anterior oblique projection. The upper portion of minor papilla can be identified by the umbilication. The lower margin of the elevated mucosa about it forms the upper limb of the (somewhat distorted) ϵ. The less prominent major papilla forms the lower limb. Note the characteristic "tongue" of barium between the limbs.

terprets this statement to mean that the papilla remains fixed while the surrounding duodenal wall is displaced inward by pressure of the enlarged pancreatic head. Templeton implies the more reasonable assumption that this tongue is barium in the ampulla or in the umbilication caused by the edema of the margins. An important clue is provided by Feldman's Case 6, which is entirely classical in appearance. In this case the central umbilication of the major papilla can be seen precisely in the middle of the lower limb of the ϵ due to the fact that it is seen partially *en face* and partially in profile. The same is shown in Figures 1, 4 and 6 of this report. Here the triangular collection of barium enclosed between the folds forming a frenulum about the ostium of the ampulla definitely localizes the ostium. Feldman's Case 4 shows a small polypoid shadow *en face* which disappears in the oblique view and probably becomes the upper limb of the ϵ.

Although it is true that a minute fleck of barium in the center of an enlarged papilla is a frequent finding, the size of the papilla seen *en face* corresponds to the lower lip of the ϵ and not its entire length. The umbilication seen *en face* is also too small to account for the stem. Moreover, the tip of the

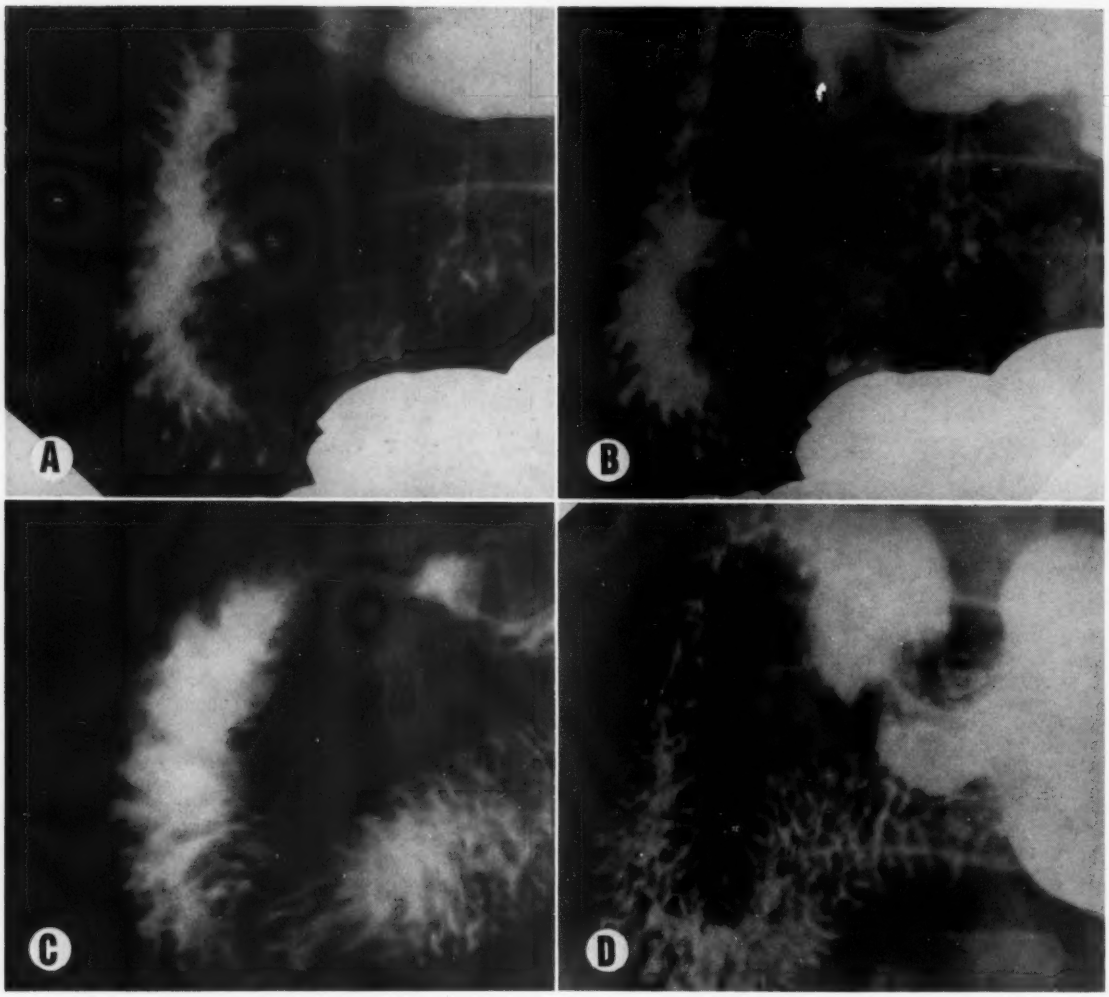

FIG. 4. *A* and *B* are views with graduated compression showing an ϵ configuration with an unusually long stem. *C* enables one to identify the umbilication of the major papilla and also shows a polypoid filling defect similar to that seen in Figure 1 and in Feldman's Case 7. This view is made with compression. *D*, seen through the overlying normal mucosal pattern, shows that the minor papilla is completely and the major papilla partially obscured.

stem is usually sharp and "cut-off," not oval as would be the case with barium in a dilated ampulla. Finally, both the stem and the major papilla are shown in Figure 1 to be widely separated.

These negative considerations account for the lower limb of the ϵ and also suggest a key to the proper interpretation of the stem and upper limb.

Obviously, the correct explanation of these shadows must be found in the anatomy of this segment of the duodenum. The solution is evident on inspecting any anatomical drawing of the region. *The lesser papilla is the only anatomical structure in the region which perfectly meets the criteria for an adequate explanation of the entire configuration.* It is normally situated 1.8 cm. (Poppel[8]) orad to the major papilla and somewhat ventrally with respect to it. According to Keyl,[6] it occurs 1 cm. below the genu of the duodenum in the great majority of cases.

It is apparently not generally recognized that the minor papilla can be identified roentgenologically. Anatomical studies in-

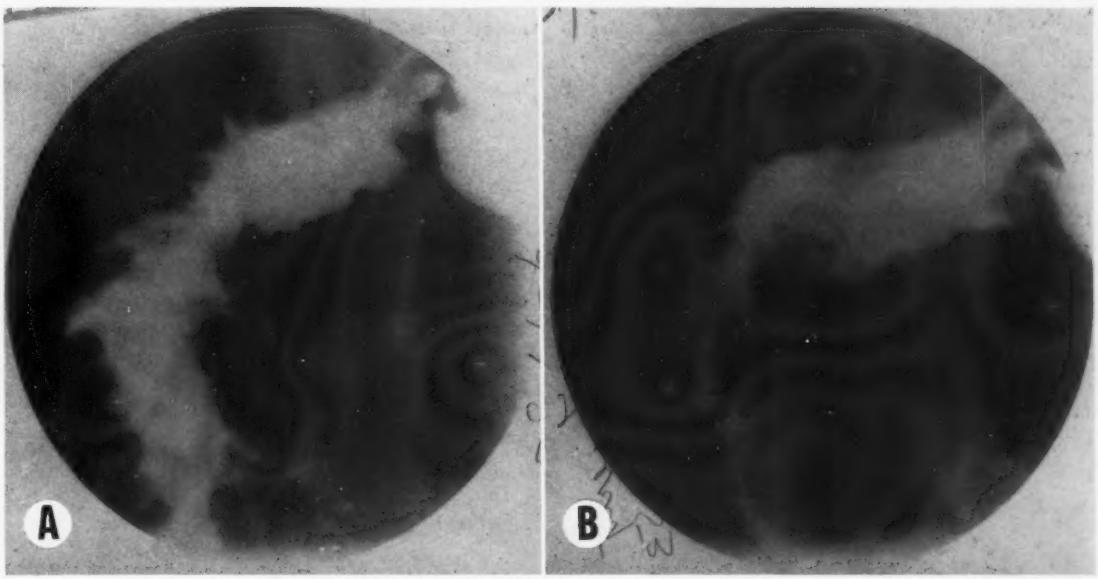

Fig. 5. This patient had occasional epigastric pains varying from a dull ache to a sharp ache with occasional soreness or burning. *A* shows a somewhat irregular epsilon deformity just below the knee of the duodenum. In *B*, made with compression, the configuration is emphasized. The patient stopped smoking and received medical management which did not differ from the ordinary peptic ulcer regimen. When seen again, after an interval of four and one half months, he was asymptomatic; no trace of the epsilon configuration was seen nor could either of the papillae be demonstrated.

dicate that it is present in nearly all normal individuals. It was found in all of Poppel's 100 anatomical specimens.[8] Of Keyl's 121 specimens it was present in 96 per cent. On the other hand, the former author, in his exhaustive monograph, does not show a single roentgenologic demonstration in a living subject.

Such demonstrations are not lacking, however. Paltrinieri,[7] in 1942, was the first to describe the roentgenologic appearance of the lesser papilla and presented 5 cases. Bauman,[1] in 1948, reported 2 cases and mentioned having seen a total of 10. Most recently, Roeckerath[9] presented 7 cases in which the minor papilla was demonstrated in the living subject by roentgenologic means. Apparently, no examples are recorded in the English literature unless one includes a case shown by Templeton, a keen observer, as an "impression of unknown origin in the duodenum." This case is illustrated in Figure 100-*a* of Templeton's monograph, and although attributed to "a gland of extrinsic origin," the filling defect has margins quite discrete enough to indicate that it is of mucosal and not extramucosal origin. It could no longer be demonstrated after eight months, which is also suggestive evidence that it was edematous from the start.

It would be difficult to add anything to Roeckerath's excellent discussion of the criteria for diagnosis of minor papilla and the differential diagnostic considerations to be excluded except to say that his cases and those of the authors he quotes may be examples of unusually large and perhaps edematous minor papillae. Figure 2 best illustrates the appearance of such lesser papillae. It is entirely typical of the cases shown by Paltrinieri, Bauman and Roeckerath. That it is only the fifteenth such case to be reported should not be considered evidence that it is an exceedingly rare phenomenon.

Figure 1 illustrates how a minute examination of the deformed duodenum precisely accounts for the morphology of the ϵ sign: (1) the major papilla forms the distal

loop; (2) the minor papilla forms the proximal loop, and (3) the pocket between the papillae and the medial wall of the duodenal lumen forms the "stem." Needless to say all of the structures concerned are enlarged as a result of edema which is presumably inflammatory. That this case is not unique can be seen by reference to Feldman's Case 4 in which the identical, small mammillary elevation above the major papilla is easily visible in the reproductions. Feldman's Figure 7 is a similar case in that it illuminates the anatomical basis for the epsilon configuration. The minor papilla is also shown in Figures 2, 3, 4 and 5.

DISCUSSION

These evocative cases suggest: (1) That standards of size of a normal major papilla should be revised downward. (2) That inflammatory disease of the second portion of the duodenum is not as rare as a perusal of the literature would lead one to suspect. (3) Unfortunate, erroneous exploratory laparotomies may be avoided by proper evaluation of the detailed morphology of the second portion of the duodenum in the presence of an epsilon configuration.

That 4 such cases should be encountered in a period of eight months by a single observer, suggests that the ε sign is much more frequent than would be suspected from the scanty reports in the literature. Certain technical aspects must be adhered to in order that the findings are not overlooked. The upper gastrointestinal examination should not stop when the status of the bulb has been determined. The second portion of the duodenum should be investigated with the same care as the first, if only because duodenitis and ulcer are not infrequent findings. It should be viewed in all projections with *graduated* compression. A most important technical aid to visualization of morphological detail in the second portion of the duodenum is re-examination after an interval of twenty to thirty minutes. At this time the peristaltic activity of this segment will be found markedly diminished in most persons. Tone is also greatly decreased as the jejunum becomes filled. These two effects permit a facile examination without the usual hindrances which have given the second segment of the duodenum its reputation for difficulty.

CLINICAL SIGNIFICANCE

Although the chain of evidence is, perhaps, not entirely complete, a number of facts speak quite clearly for the hypothesis that this configuration is pathologic even if of less serious consequence than neoplasm. Each of the patients shown in Figures 1, 3, 4 and 5 had definite clinical symptoms which were relieved by a peptic ulcer regimen. The complete regression in some cases and partial regression in others leaves no doubt that the morphology was altered by treatment in the direction of a return to a more normal appearance. In one patient, the return of the ε sign coincided with an exacerbation of symptoms. Finally, the association with enlarged folds of mucosa in the second portion of the duodenum further correlates these changes with edema of presumably inflammatory origin in this region.

Classifying these changes as of inflammatory or edematous origin, of course, explains nothing with regard to the genesis of the condition. Perhaps most commonly, the etiology is similar to that of duodenitis, whatever that may prove to be. Certainly pancreatitis could be an associated abnormality, either secondary to duodenitis or causing it. Edema secondary to carcinoma of the pancreas cannot be excluded, nor can edema associated with a carcinoma of the ampulla or terminal common bile duct be excluded. It seems likely, however, that the latter will, in general, originate on the mucosa of the papilla in some segment and grow peripherally. This will result, as a rule, in an asymmetrical papilla and from a diagnostic point of view, asymmetry of the major papilla is of considerably more significance than mere enlargement. This has been well shown by Poppel. Case 6 (Fig. 6) illustrates how little an enlarged neoplastic

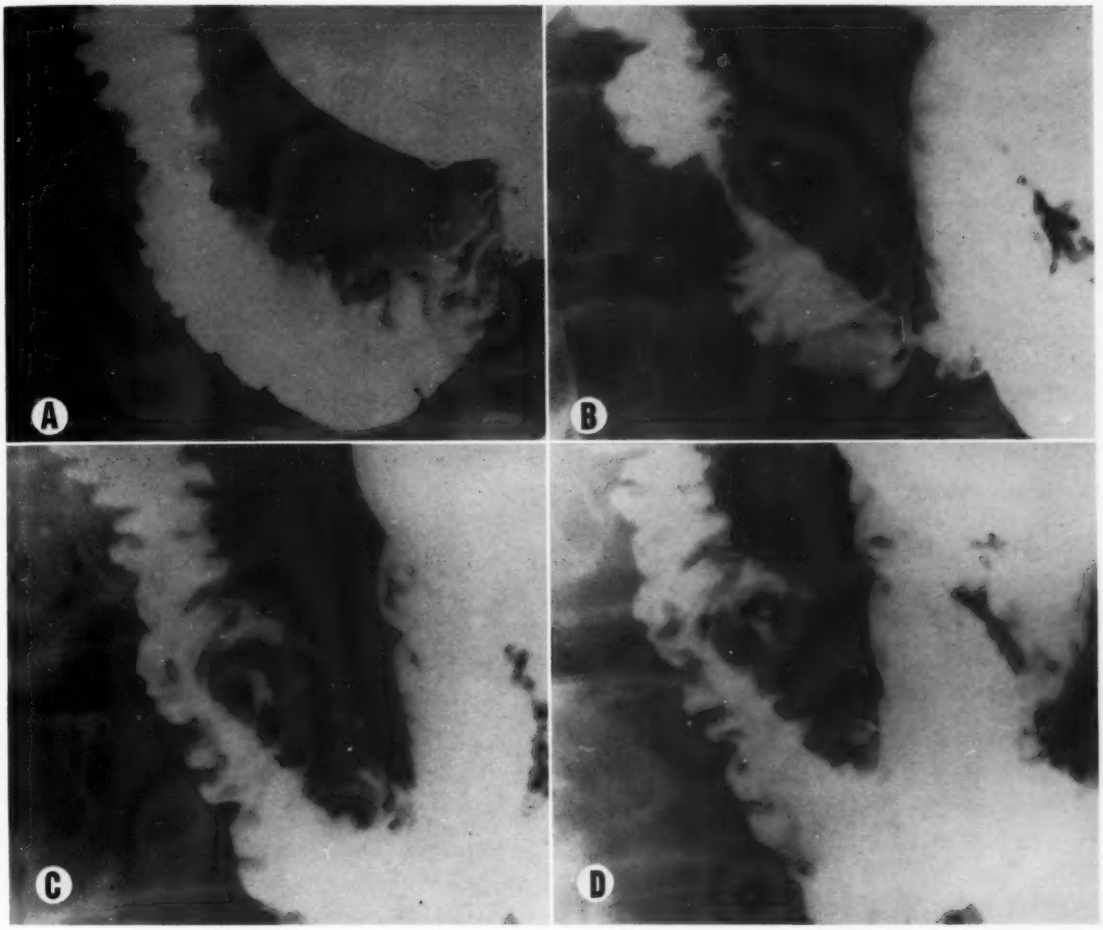

Fig. 6. These views are of the second portion of the duodenum of a fifty-three year old woman with subclinical jaundice and occult blood in the stools. *A* and *B* show an irregularity of the medial aspect of the distal half of the second portion of the duodenum tending to involve also the initial few centimeters of the third portion of the duodenum. Note that although the margin is irregular it would require a considerable stretch of the imagination to construe this as a real epsilon configuration. *C* and *D* are "twist stereos" of the lesion as seen *en face* with compression. The irregularly triangular central umbilication identifies the midpoint of the papilla. The papilla is moderately enlarged. The significant feature here is the extension of the filling defect distally. Thus, it cannot represent the minor papilla. Hence, by exclusion the filling defect must be neoplastic. It was so proved at laparotomy. Reference to *A* and *B* illustrates that when the papilla is enlarged by neoplasm, the lips about the opening of the ampulla do not form an epsilon when seen in profile.

papilla differs from an edematous papilla. The asymmetrical extension of the filling defect into the third portion of the duodenum was the diagnostic feature in this case.

How can one safely thread his way through this complex morphology without over-diagnosing or under-diagnosing? The safest formula I have been able to arrive at is to:

(1) Observe a meticulous technique, particularly in securing numerous spot films, preferably about twenty minutes after the first swallow of barium in order that adequate detail will be available for forming an opinion.

(2) Regard the epsilon sign as due to papilloedema without initially attempting to decide whether the edema is incident to duodenitis, ampullary or pancreatic carci-

noma, or pancreatitis. This decision should be reserved pending further studies. These should include a cholecystogram, a search for occult blood in the stools and bile pigments in the blood, as well as laboratory investigation of the possibility of pancreatitis. An abnormal gallbladder will favor neoplasm or pancreatitis, depending upon whether it is nonfunctioning or contains stones. It also provides a good indication for an immediate laparotomy at which a duodenotomy can also be performed and the pancreas palpated. Jaundice, either clinical or subclinical, if associated with occult blood, should also indicate exploratory laparotomy.

(3) A number of cases will remain showing none of these findings or only occult blood in the stools. These should be placed on a peptic ulcer regimen and re-examined at weekly intervals. If no regression is observed in a period of four weeks, duodenotomy is probably indicated. The admonition is necessary that complete regression should not be expected as the major papilla, and, in my opinion, the minor papilla as well, can be demonstrated in a normal person. Consequently, the "ϵ sign" can also be anticipated in normal persons.

(4) Asymmetrical enlargement of the major papilla should be regarded as an indication in itself for duodenotomy.

(5) An enlarged minor papilla alone may indicate that Santorini's duct is the main outflow tract of the pancreas. Keyl found this to be the case in 8 per cent of his material. In such cases the common duct may enter the duodenum at the *minor* papilla. A surgeon operating in this vicinity would be well advised to keep this possiblity in mind as resection of the ampulla has actually occurred with fatal results.[2]

SUMMARY

After a review of older theories regarding the origin of the double scallop of the convexity of the duodenal loop to which the designation "Frostberg's sign" has been given, evidence is presented which indicates that this configuration is actually due to edema of the minor and major duodenal papillae. A number of typical cases are presented and among these are the first examples of demonstrable minor duodenal papillae to be recorded in the English literature. The clinical significance of such findings and the management of doubtful cases is discussed.

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Vol. 75, No. 2

ROUTINE BARIUM-GAS EXAMINATION OF THE DUODENAL BULB*

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EVALUATION of the duodenal bulb is often difficult. Frequently, this structure is inaccessible to palpation and compression. Hampton[1] described an air contrast technique for study of the duodenal bulb without compression. This has since been used primarily in patients with recent gastrointestinal bleeding.[2] We at first used the air contrast examination as an accessory technique, but it is now employed in every upper gastrointestinal study. Routine use was prompted by the discovery of a number of posterior wall duodenal ulcers which were not demonstrated by any other techniques.

This paper is presented in order to review the barium-gas technique, to point out the multiplicity of its uses, and to urge its routine use in examination of the upper gastrointestinal tract.

TECHNIQUE

We have made only minor modifications in Hampton's basic technique which consists of films made in the supine oblique position. We shall outline the technique in current use in this department.

After the esophagus, stomach and duodenum have been examined with barium in the usual manner (including pressure films of the stomach and duodenal bulb in the erect position), the patient is given *one ounce* of a carbonated beverage and the table is brought to the horizontal position. This amount of beverage neither obliterates the mucosal pattern nor dilutes the barium appreciably. When there is a large natural gas bubble in the cardia, the carbonated beverage is omitted

STEPS

1. The patient, in the supine position, is rolled briefly to his right in order to fill the bulb with barium

2. The patient is rolled toward his left (right anterior oblique with respect to the fluoroscopic screen) until the gas rises into the antrum and bulb. Usually the bulb is seen projected through or just to the left of the spine.

3. Spot films are made in rapid succession. Photo-timing is a great convenience, and a rotating anode tube under the table provides excellent detail.

4. If the gas does not enter the bulb promptly, the left lateral position may be utilized.

After this procedure, which should not require more than two or three minutes, the remainder of the conventional upper gastrointestinal examination is carried out, including study of the esophagus, stomach and duodenum in supine and prone oblique projections. It should be emphasized that films in the "bulb up" position augment but do not supplant any of the usual procedures in thorough examination of the upper gastrointestinal tract.

COMMENT

The relationship of the gas to the barium coated mucosa with the patient in the supine oblique position is shown in Figure 1. The weight of the barium in the fundus and pars media pulls the stomach to the left and exerts traction on the duodenum. The second portion of the duodenum is fixed retroperitoneally and there is actual stretching of the bulb with resultant straightening of the duodenal "elbow." The latter term is used to designate the posterior angulation at the junction of the bulb with the second portion of the duodenum. This angle is often exaggerated by attempts at compression in the erect position but it is straightened in the supine oblique position.

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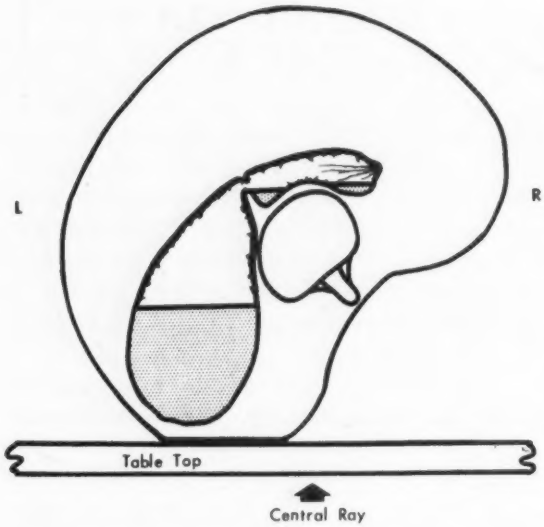

FIG. 1. Cross sectional line drawing at bulb level with patient in "bulb up" position. The barium (shaded) in the fundus pulls the stomach to the left, exerting traction on the bulb and causing straightening of the duodenal "elbow."

EVALUATION AND INTERPRETATION OF BARIUM-GAS CONTRAST FILMS

A film of good diagnostic quality shows the bulb coated with a thin film of barium, distended with gas, and somewhat elongated as the result of traction (Fig. 2). Too much or too little barium or gas detracts somewhat from the diagnostic quality but seldom renders the view useless.

On inspection of the film, the gastric antrum, the pylorus and the bulb are almost invariably easily identified. The duodenal bulb can be evaluated even though it is projected through the spine, the descending duodenum or the jejunum. Often, there is little or no mucosal pattern and there is but slight tendency for barium to become trapped between mucosal folds. Usually the folds of mucosa converge toward the duodenal "elbow."

One must always identify the junction of the bulb with the second portion of the duodenum. In certain cases this duodenal "elbow" may be seen on end and unless it is properly identified it may be mistaken for an apical ulcer. Occasionally, the change from wide to narrow lumen and the concentric sworled mucosal folds at the apex may simulate a polyp. Before making a diagnosis of ulcer or polyp (which is not also seen on pressure views) it is imperative to show on multiple films that the lesion in question is not the duodenal "elbow." In Figure 3 we present two films which might lead to confusion if the view is seldom used.

Ulcers on the posterior wall stand out sharply. Several are shown in Figure 4. Often, the mucosal folds radiate toward the crater but in some cases (Fig. 4a) there is no mucosal pattern. Craters should, of course, be demonstrated on multiple films. Anterior wall ulcers which do not retain barium are not demonstrable in this projection.

Familiarity with the view and its routine use in patients of different habitus promotes adroitness in filming and ease of interpretation. If films of good quality are secured, they present no real problem in evaluation.

APPLICABILITY OF THIS TECHNIQUE

In general hospital radiological practice we have found that satisfactory barium-gas contrast films of the bulb were obtained in 90 per cent of patients. The failures (10 per cent) were attributed to: (a) pyloric obstruction; (b) previous gastric surgery; (c) non-cooperative patients (breathing, etc.).

It is worthy of mention that the excellence of conventional compression films of the bulb is largely limited by patient habitus and bulb position. Barium-gas contrast films, however, can be obtained in patients of every habitus regardless of bulb position. For this reason, the barium-gas views are of particular value in the study of bulbs which are difficult to examine by other means.

In our series it was found, by study of consecutive patients, that the bulb was inaccessible for adequate palpation and compression in 22 per cent. Critical review of this group of "problem patients" revealed that adequate air contrast views

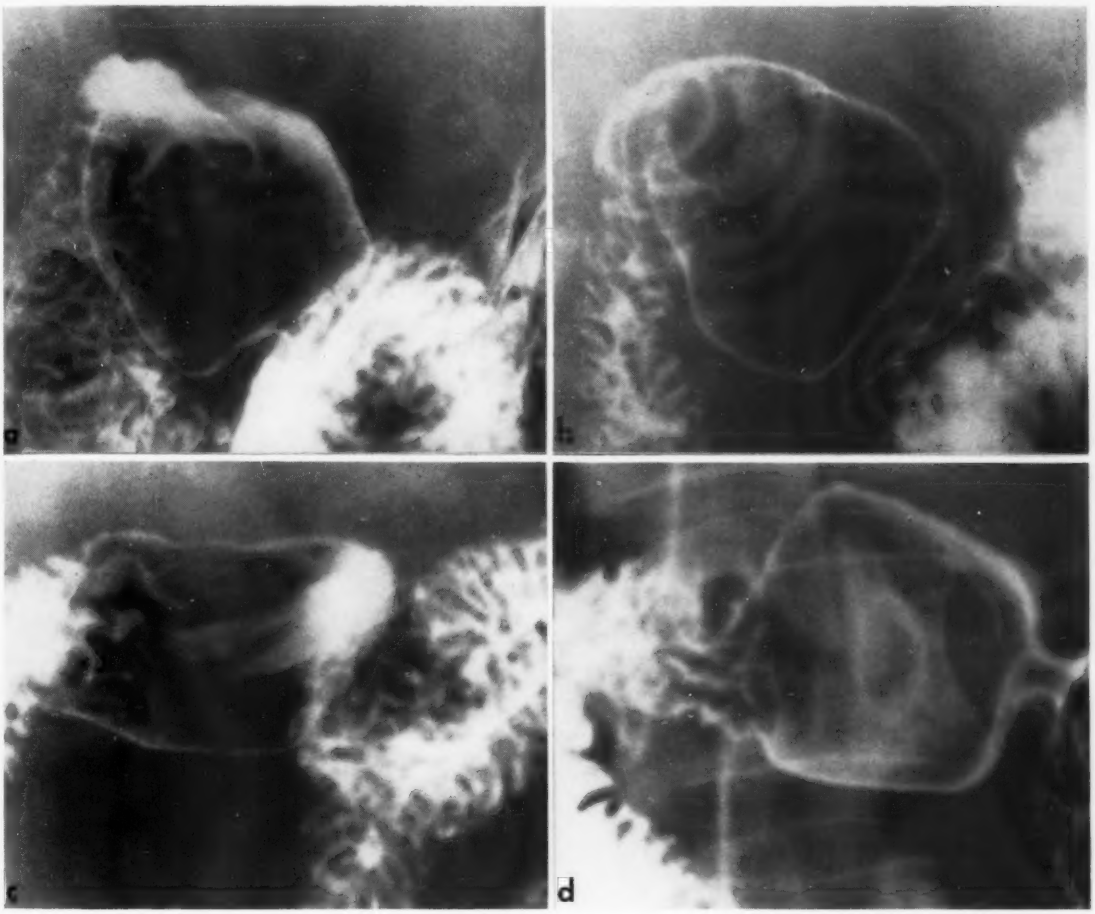

FIG. 2. Normal duodenal bulbs filmed in the "bulb up" position. Patients are of different habitus. The bulb is usually seen best to the left of the spine as in *a*, *b* and *c*. In *d*, it is projected through the spine without loss of detail.

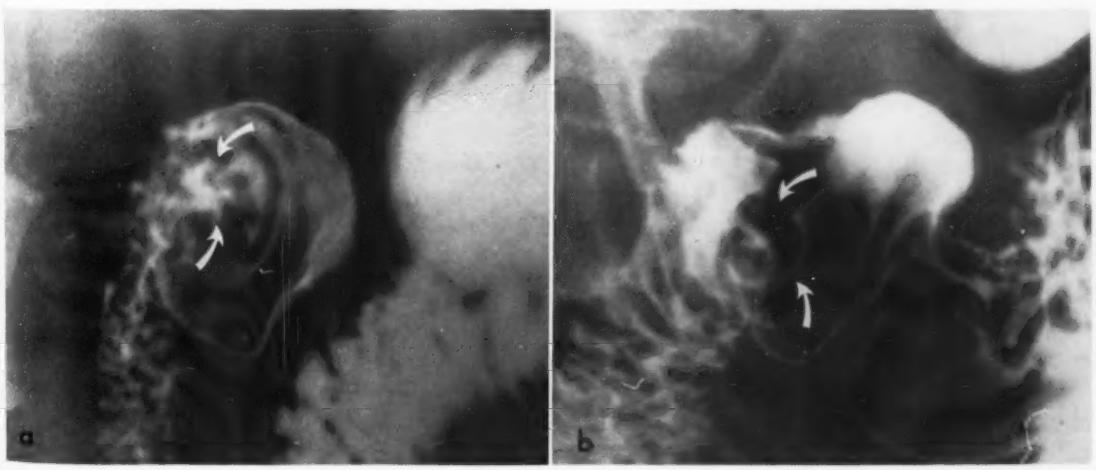

FIG. 3. Duodenal "elbows" seen on end. Here the second portion of the duodenum is inadvertently projected through the bulb in such a way as to suggest an ulcer (*a*) and a polyp (*b*).

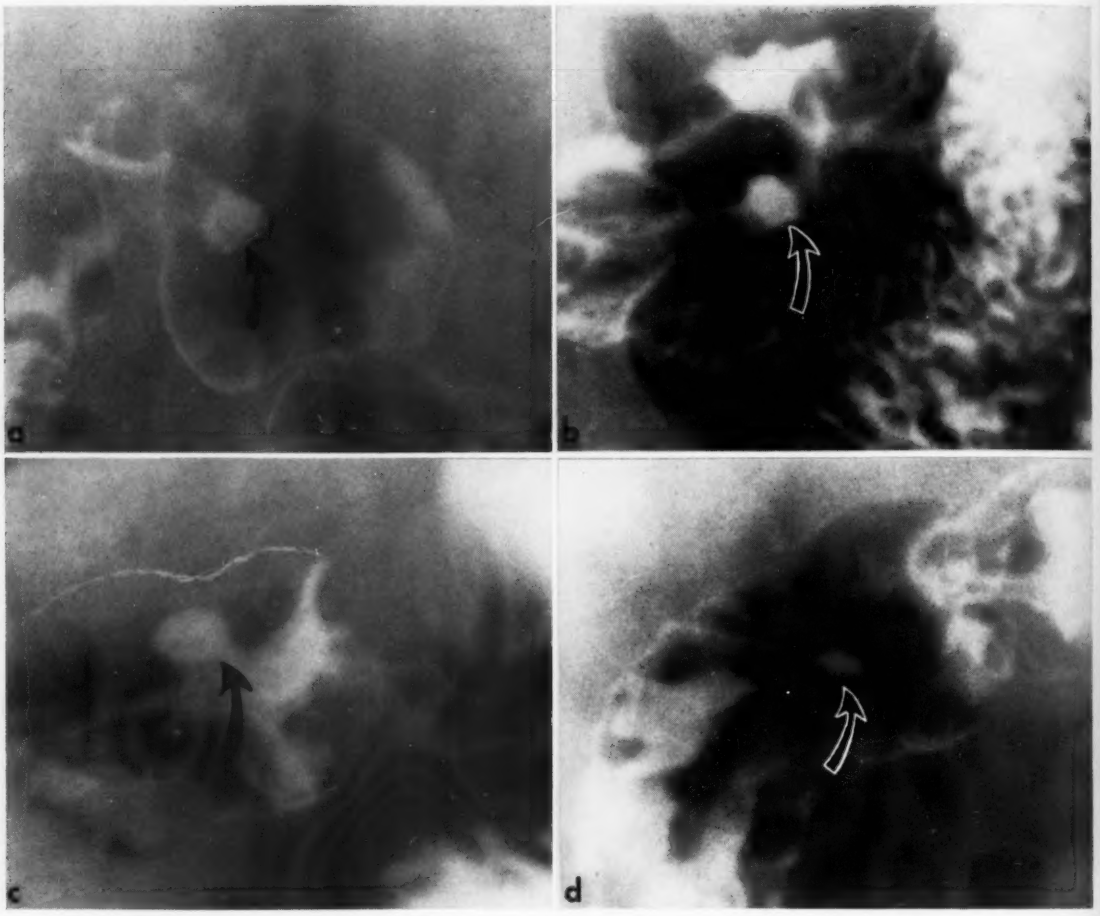

FIG. 4. Four posterior wall duodenal ulcers shown by barium-gas technique. The bulb in *c* was retouched to indicate the upper margin of the gas.

were secured in 94 per cent. When the bulb is inaccessible, particular care in the use of gas contrast is well worth while.

VISIBILITY OF CRATERS

Review of the films of the last 50 consecutive patients harboring duodenal ulcer craters, 75 per cent of which were on the posterior wall, disclosed the following: (a) The crater was seen both on compression films and on barium-gas contrast films in 85 per cent. (b) Posterior wall craters were shown better by gas contrast than by other methods in 65 per cent. (c) The crater was shown *only* on compression films in 5 per cent. (These were anterior wall craters.) (d) The crater was shown *only* on barium-gas contrast films in 10 per cent. (In none of these patients was the bulb accessible to satisfactory compression).

The above figures illustrate some of the advantages of the technique. In the last year, we discovered eight ulcers in this manner which were not otherwise identified. Two of them are illustrated in Figure 5. In each case the bulb was inaccessible to compression.

INDICATIONS

A. Primary Indications. The barium-gas contrast technique is specifically indicated in examination of the duodenal bulb under the following conditions:

1. When deep palpation and compression are contraindicated (active bleeding, recent hemorrhage, postoperative).

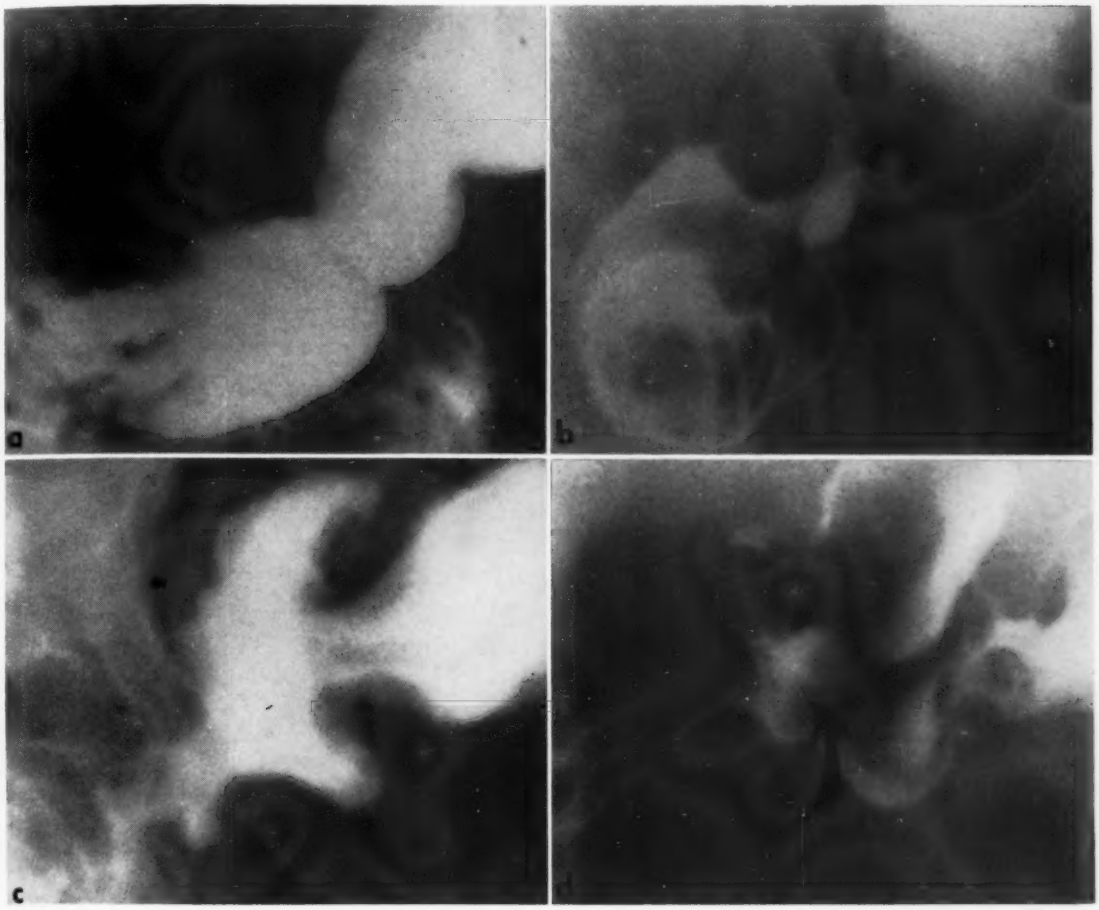

FIG. 5. Comparison of techniques. The films on the left represent the best pressure spots which could be obtained in two patients. The bulbs were inaccessible. The same bulbs are shown on the right using the gas contrast technique. The ulcer in *b* is in the pyloric canal; the one in *d* is at the apex of the bulb.

2. When the patient is unable to stand.

3. When the bulb is high under the ribs or is situated posteriorly, making it inaccessible to palpation and compression in any position.

4. When the crater is not convincingly demonstrated by other methods.

B. Secondary Indications. In addition to the above, it is our belief that the "bulb up" view is of value even if all other views are entirely satisfactory and the bulb is accessible to compression. Some of the reasons for our preference are listed below:

1. About 10 per cent of duodenal craters can be shown in no other way.

2. Craters on the posterior wall are often more strikingly and accurately shown than on compression films.

3. Apical duodenal ulcers are more reliably evaluated as the result of the traction effect mentioned above. When these occur near the duodenal elbow they are difficult to delineate clearly by other means.

4. Pyloric craters are often more sharply outlined when they are contrasted with gas than in other views.

5. In deformed bulbs the gas-filled film is of value in differentiating between pseudodiverticula and craters.

6. Negative barium-gas contrast views have great "reassurance value."

7. Posterior wall ulcers can be differentiated from anterior wall ulcers.

8. Prolapsed gastric mucosa, and duo-

denal filling defects such as adenomata are demonstrable with unusual clarity in the gas filled bulb.

SUMMARY

Barium-gas contrast study of the duodenal bulb is of primary value when the bulb cannot be compressed or palpated adequately. It is of secondary value in a wide variety of circumstances and in differential diagnosis. A significant number of craters have been discovered by use of this technique which were not demonstrable in conventional views. It is highly recommended in routine examination of the upper gastrointestinal tract.

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PSEUDO-ULCERATION OF THE STOMACH AND DUODENUM PRODUCED BY TRACTION DIVERTICULA*

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REFERENCES to traction diverticula of the stomach and duodenum in medical literature are infrequent, casual, and not in keeping with the importance of these asymptomatic lesions. The roentgenologic morphology of traction diverticula is in many respects confusingly similar to that of benign peptic ulceration of the stomach and duodenum. The confusion is abetted by the fact that these diverticula tend to occur in persons suspected of having ulcerative disease. In fact these lesions often represent a residual effect of previous perforation or penetration of peptic ulcers. All of the cases reported in this communication were originally diagnosed incorrectly as benign peptic ulcers. By retrospective study of these cases, however, certain anamnestic and roentgen characteristics of traction diverticula have been recognized which serve to differentiate the lesions from peptic ulceration.

The importance of differentiating a diverticulum from an ulcer is that roentgenologic demonstration of a gastric ulcer is adequate indication for surgery in some clinics, regardless of the patient's symptoms or lack of them. The failure of a gastric ulcer to heal within an arbitrary period of time, even though it may appear benign, constitutes a clear necessity according to most surgeons for exploratory laparotomy. One of the characteristics of traction diverticula is the constancy of the deformity which can easily be misinterpreted as an ulcer that is medically refractory. The radiologist's familiarity with the features which serve to differentiate traction diverticula may save the patient from formidable surgical procedures or from a strict regimen that demands the forfeiture of social pleasures and may jeopardize economic security. No therapy is indicated for a traction diverticulum.

A traction diverticulum as referred to herein is a localized evagination of the stomach or duodenum which is produced by fibrous bands that are adherent to the serosal surface and exert an outward pull on the wall. These are true diverticula since all of the mural layers are intact. Pathogenetically, an episode of inflammation results in a proliferative fibroplastic response and consequent contraction of the fibrous strand distorts the wall of the stomach or duodenum; thus, the diverticulation is acquired. Most of the acquired diverticula of the stomach are the traction variety.[3] Two of the patients reported in this manuscript had previous perforations from gastric ulcers and two had operative procedures in the epigastric field. No prior extragastric inflammation could be determined in the fifth case.

Seven gastric and duodenal traction diverticula have been demonstrated in these 5 patients. Each of these patients was subjected to repeated roentgenologic study of the gastrointestinal tract and each (except Case IV) had subsequent operative procedures from which the diagnosis was established. A brief summary of the case histories of the 5 patients will be reviewed with reference only to pertinent clinical and pathological observations. The roentgenograms of each are shown. Two additional cases of traction diverticula of the stomach, diagnosed preoperatively as gastric ulcers, were demonstrated at operation but are not included in this report since the roentgenograms are not available.

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FIG. 1. Case 1. Initial gastrointestinal series. Note the extraluminal pouch (white arrows) on the lesser curvature and another pocket projecting posteriorly (black arrows). The duodenal cap is deformed.

REPORT OF CASES

CASE 1. B. H., a colored male, aged fifty-three. The patient's first admission was on September 27, 1953, when the diagnosis of a perforated gastric ulcer was made. Exploratory laparotomy disclosed the perforation on the lesser curvature of the stomach approximately 2 cm. proximal to the pylorus, and a Graham type of closure was performed. The recovery was uneventful and the patient was discharged for follow-up study in the surgery clinic. An elective gastric resection was proposed for a later date.

On November 5, 1953, an upper gastrointestinal series was performed (Fig. 1). The films of a repeat study the following day are illustrated in Figure 2. The stomach demonstrated retention and/or hypersecretion of gastric juices. The rugal pattern was coarse and irregular. Peristaltic activity was sluggish, incomplete, and intermittent, and a delay in the gastric emptying time was observed. The duodenal cap was grossly deformed. At roentgenoscopy, and demonstrated repeatedly on serial films, were two localized outpouchings separated by 3–4 cm. on the lesser curvature and posterior wall of the stomach, respectively, near the junction of the cardia and pars media below the esophageal entrance. The barium solution was retained in each of these craters persistently and in profile the craters projected extraluminally. The roentgen interpretation listed two benign ulcers of the stomach, gastritis, and duodenal bulb deformity without demonstrable crater formation.

The patient was readmitted and surgery was performed on November 11, 1953. The site of the perforation in the antrum of the stomach had completely healed, but there was an omental tag firmly adherent to the serosal surface of the stomach at this point. The first part of the duodenum was scarred. In the upper portion of the stomach, identical anatomically with the two craters demonstrated roentgenologically, were two dense fibrotic bands adherent to the stomach and producing retraction and puckering of the gastric wall. A subtotal gastrectomy was performed and the pathologic report of the surgical specimen described chronic gastritis without evidence of ulceration.

CASE II. E. M., a white male, aged fifty. The patient was first admitted in November, 1953, with the complaints of nausea, vomiting, and epigastric pain for three weeks and hematemesis for four days. The patient had a history of two previous perforations which had been surgically closed. Vagotomy and subtotal gastrectomy had been performed three years ago in another hospital. Subsequently, he had never been free of symptoms. An upper gastrointestinal series (Fig. 3) on November 16, 1953, demonstrated a persistent, localized collection of the barium solution on the lesser curvature of the stomach above the gastrojejunostomy. The evagination appeared to project beyond the confines of the gastric lumen. Compression failed to empty the barium solution from this site (Fig. 3*b*). Repeat gastrointestinal series (Fig. 4) on December 4, 1953, again demonstrated a persistent collection of the opaque medium trapped in an extraluminal projection at the same anatomical site.

A partial gastrectomy was performed. The surgical and pathological reports described a benign superficial ulcer of the extreme upper fundus of the stomach (not demonstrated roentgenologically) and a diverticulum of the lower lesser curvature of the stomach above the gastroenterostomy. There were dense adhesions attached to the serosa at the point where the diverticulum originated. This point coincided with the anatomic site of the crater demonstrated on the roentgenograms. There was, in addition, chronic gastritis and a microscopic jejunal ulcer adjacent to the anastomosis of the stomach and jejunum.

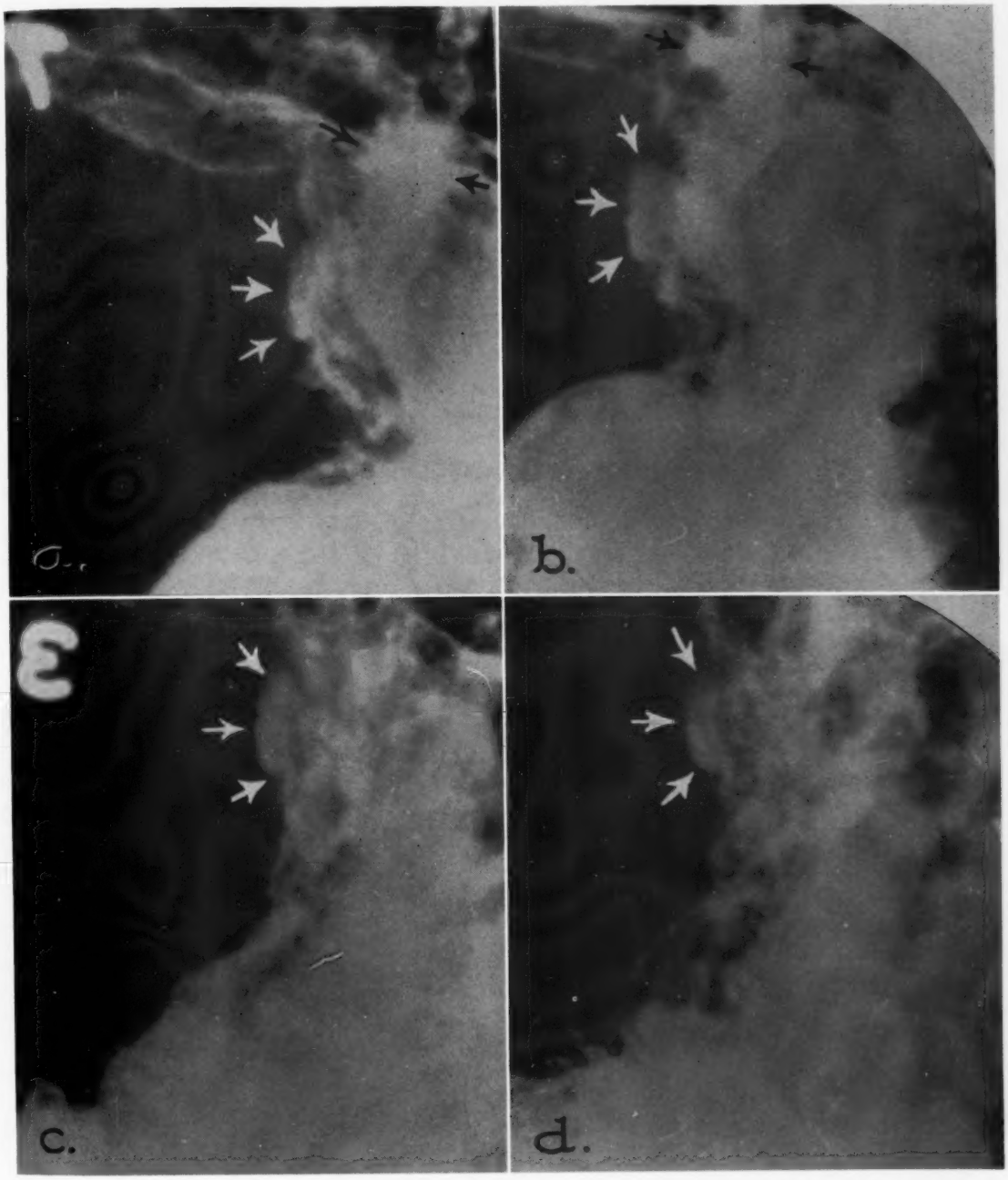

Fig. 2. Case 1. Repeat gastrointestinal series. The lesions are magnified from serial films for better study. Note particularly the absence of the usual findings of ulceration about the pocket on the lesser curvature (white arrows). As a result of poor centering, the traction diverticulum on the posterior wall (black arrows, Figures 2*a* and *b*) is not included on Figures 2*c* and *d*.

Case III. B. M., a white male, aged twenty-three. This young man was first admitted on Febuary 5, 1954, with hematemesis. When the patient was six years old, a diagnosis of Banti's syndrome was made and a splenectomy was performed. The parents were informed at this time that the boy had "scarring of the liver." The patient had one previous admission in 1951 to Parkland Hospital with the diagnosis of hematemesis from esophageal varices. At

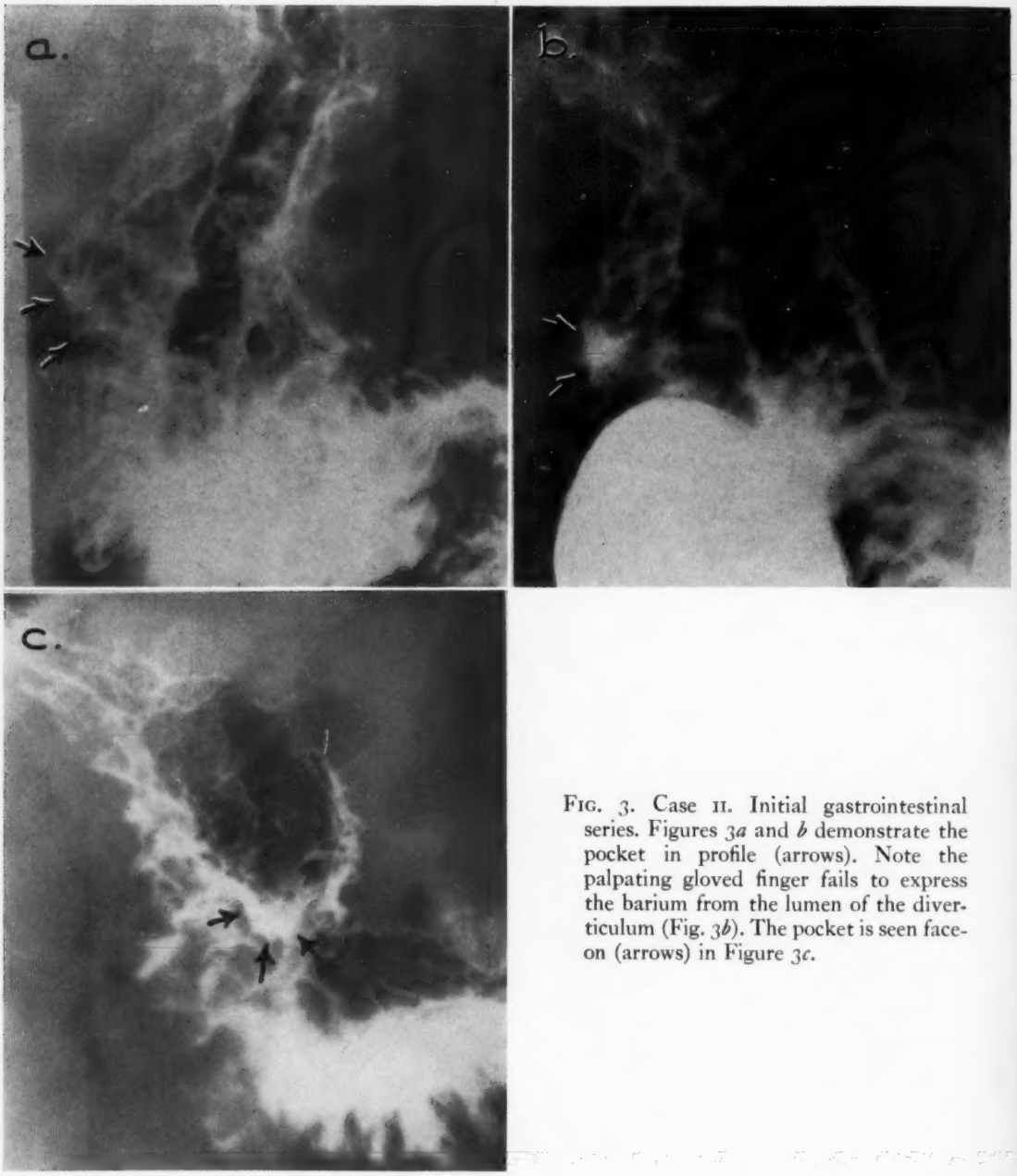

Fig. 3. Case 11. Initial gastrointestinal series. Figures 3*a* and *b* demonstrate the pocket in profile (arrows). Note the palpating gloved finger fails to express the barium from the lumen of the diverticulum (Fig. 3*b*). The pocket is seen face-on (arrows) in Figure 3*c*.

the present admission, a Blakemore tube was inserted and transfusions were given. When hemorrhage had abated, an upper gastrointestinal series (Fig. 5) was performed on February 10, 1954. The study was reported to show a persistent crater in the antrum with convergence of the large rugal folds near the base of the crater (Fig. 5*d*). This was present upon the posterior wall. There was also a small niche in the base of the duodenal cap superiorly which appeared to be circumscribed by a halo of edematous mucosa (Fig. 5*a*, *b*, and *c*). The roentgenologic diagnosis was benign ulcer of the duodenal bulb and gastric antrum. At esophagoscopy, blood was encountered in the esophagus but no varices were demonstrable. A repeat gastrointestinal series (Fig. 6) was performed on February 15, 1954. Again, no esophageal varices were disclosed at fluoroscopy or upon the serial roentgenograms. The

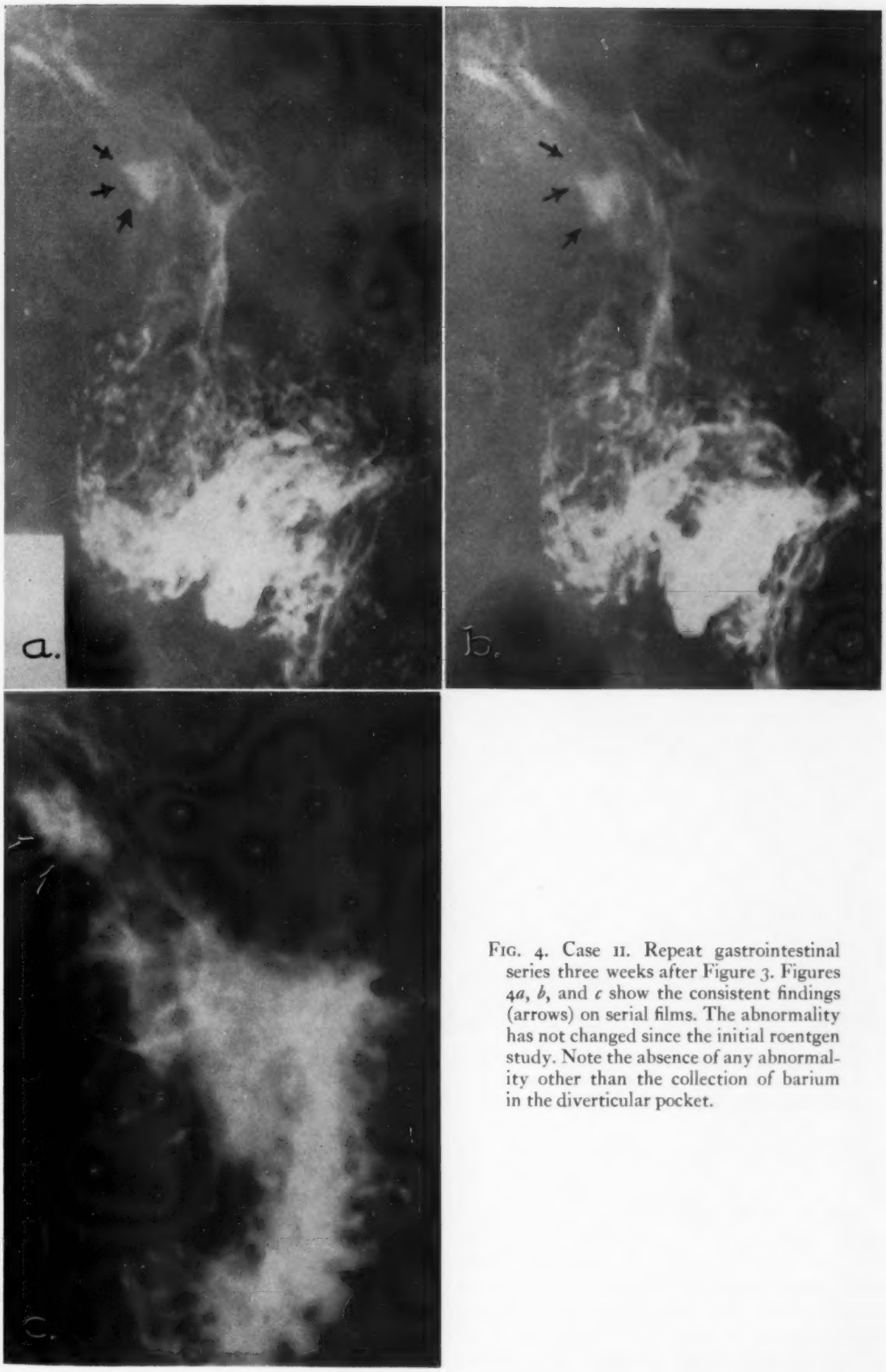

FIG. 4. Case 11. Repeat gastrointestinal series three weeks after Figure 3. Figures 4*a*, *b*, and *c* show the consistent findings (arrows) on serial films. The abnormality has not changed since the initial roentgen study. Note the absence of any abnormality other than the collection of barium in the diverticular pocket.

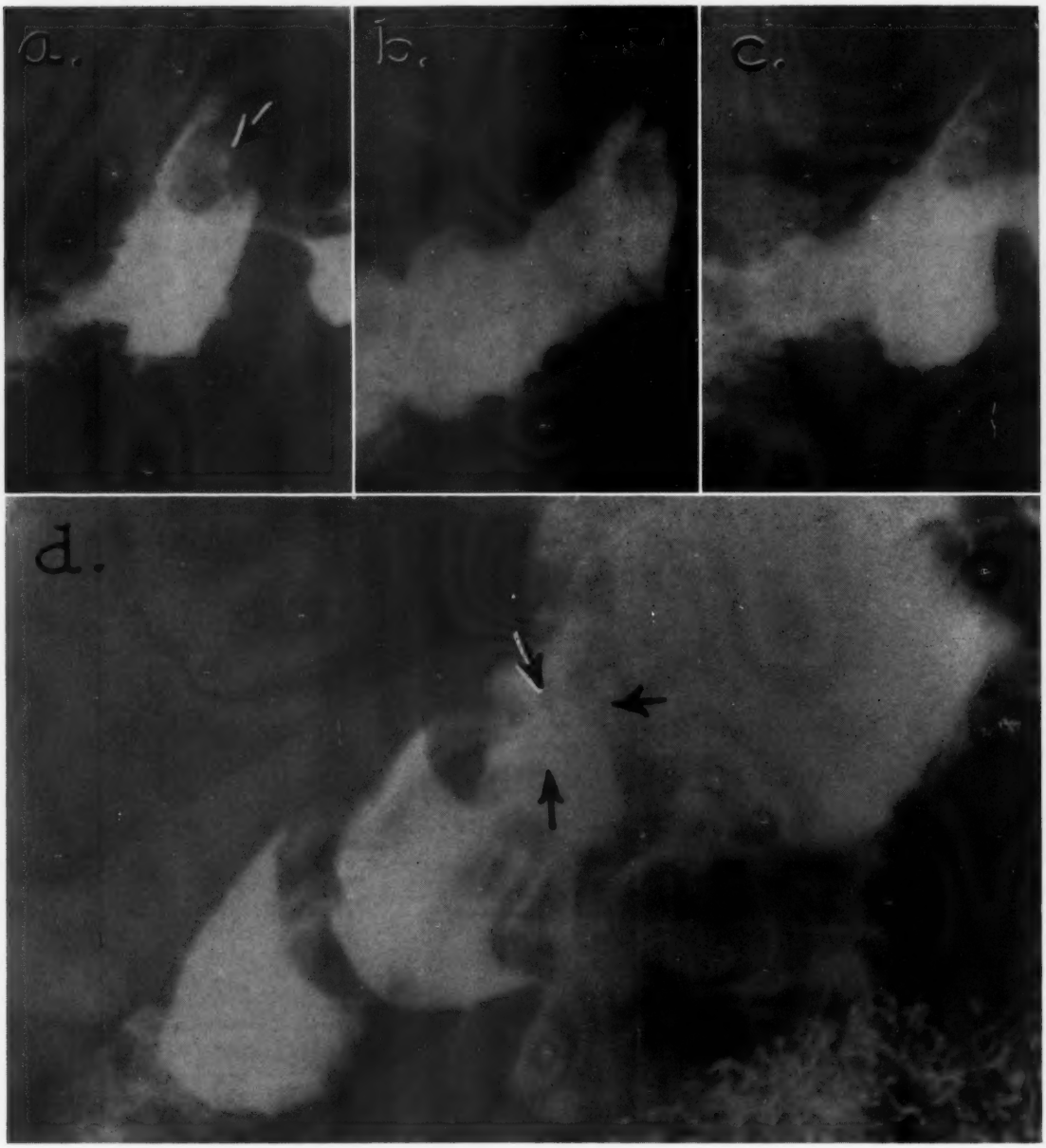

FIG. 5. Case III. Initial gastrointestinal series. Note the persistent small niche surrounded by the radiolucent area in the duodenal bulb shown by spot roentgenography in Figures 5*a*, *b* and *c*. Figure 5*d* shows the pattern in the gastric antrum that was interpreted as rugal folds radiating from the base of an ulcer crater.

abnormalities previously described in the gastric antrum and base of the duodenal cap were again demonstrated. A double contrast study of the stomach repeatedly, on serial films, identified the crater on the posterior wall of the antrum, but the rugal folds were smooth and regular at this time and showed no radiation from the base of the crater (Fig. 6*a*, *b*, and *c*).

Percutaneous portal venopuncture revealed a pressure of 220 mm. of H_2O and an attempt at portal venography was unsuccessful.

Exploratory laparotomy was recommended to determine whether the source of bleeding was from the gastric and duodenal abnormalities (that were seen on the roentgenologic studies) and/or to confirm the presence of portal hypertension. Appropriate operative measures would depend upon these determinations. At surgery, a direct measurement of the portal

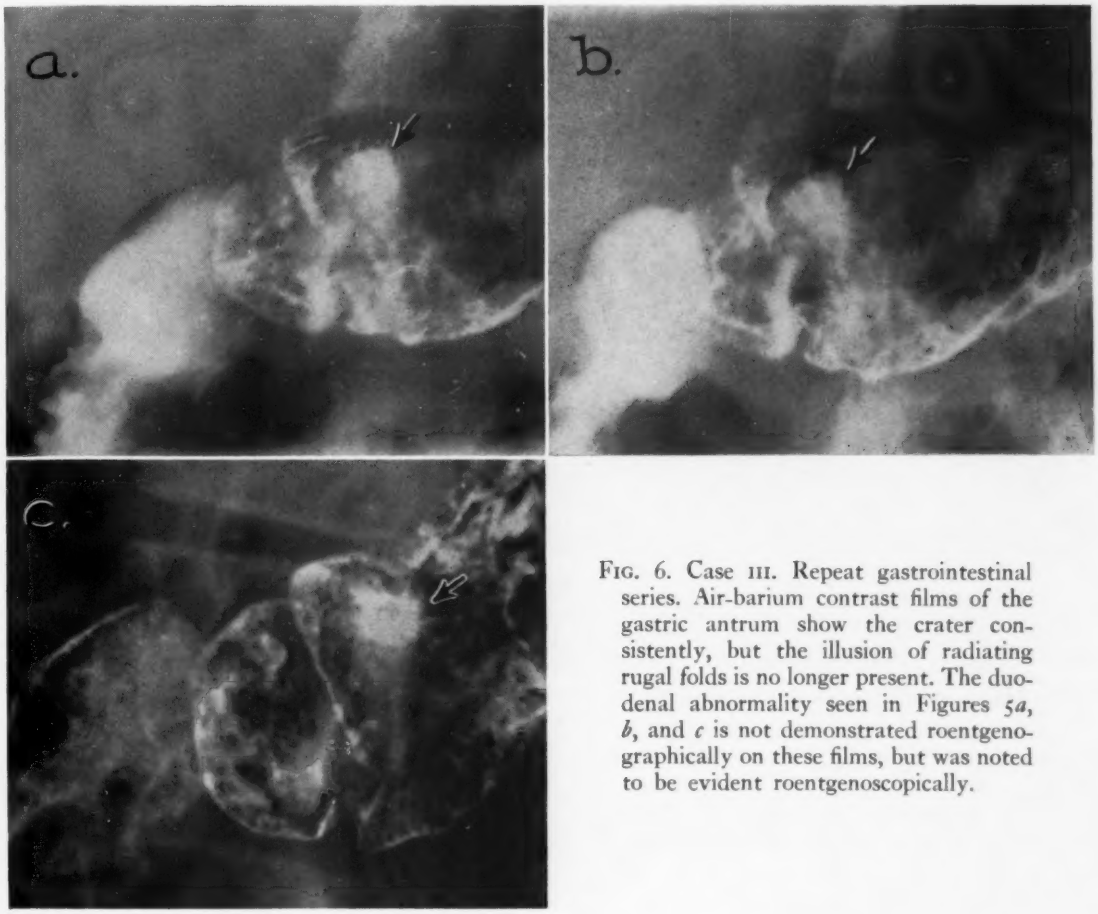

Fig. 6. Case III. Repeat gastrointestinal series. Air-barium contrast films of the gastric antrum show the crater consistently, but the illusion of radiating rugal folds is no longer present. The duodenal abnormality seen in Figures 5*a*, *b*, and *c* is not demonstrated roentgenographically on these films, but was noted to be evident roentgenoscopically.

venous pressure was 220 mm. of H_2O but no venous shunting procedure was feasible because of portal cavernomatous transformation and splenic vein thrombosis. Dense adhesions were recognized at the base of the duodenal cap and gastric antrum producing local eversions of their walls at the sites of attachment. These points anatomically corresponded to the craters demonstrated by roentgenography. No evidence of gastric or duodenal ulcer was found.

Case IV. A.P., a white female, aged seventy-three. The current illness began after a cholecystectomy done in another hospital approximately five years ago. After the operation, it was found that the common duct had been ligated and a surgical choledochoduodenostomy was performed. Subsequently, the patient had recurrent episodes of right upper quadrant pain, fever, and chills. Eventually, she was seen in Parkland Hospital and the diagnoses of recurrent biliary tract obstruction and ascending cholangitis were made. Exploratory laparotomy was performed. It was noted in the operative report that no free peritoneal cavity was encountered due to diffuse adhesions, and the liver, duodenum, stomach and all surrounding structures were covered with scar tissue. A stone was impacted in the distal end of the common duct and there was a stricture of the common duct at the site of the anastomosis with the duodenum which would admit only a 1 mm. probe. Leaving the previous anastomosis intact, the operator made another side-to-side anastomosis of the common duct and duodenum. Subsequently, the subjective and objective symptoms were relieved. An upper gastrointestinal series (Fig. 7) performed in January, 1953, demonstrated a persistent outpouching of the second portion of the duodenum approximately 2 cm. distal to the choledochoduodenostomy. This was interpreted as a large duodenal ulcer crater. The patient remained asymptomatic and a roentgenologic examination of the upper gastrointestinal

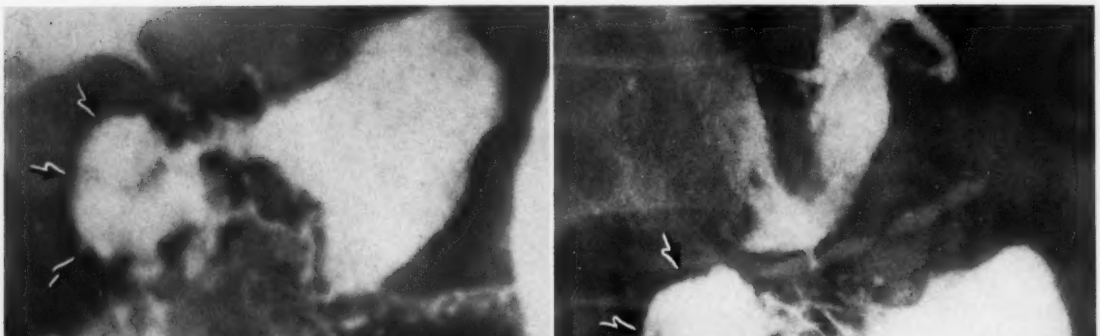

FIG. 7. Case IV. Initial gastrointestinal series. Spot roentgenogram (Fig. 7*a*) shows the barium retained in a pouch (arrows) of the second portion of the duodenum distal to the choledochoduodenostomy. The cap is filled with barium but the gastric antrum is distended with gas. Retained secretions caused flocculation of the barium solution. Postfluoroscopic roentgenogram outlines the anatomical landmarks more satisfactorily (Fig. 7*b*). Again note the saccular pouch (arrows).

tract (Fig. 8) in March, 1954, again demonstrated the persistent outpouching of the second portion of the duodenum just distal to the choledochoduodenostomy. The abnormality was interpreted, at this time, as a traction diverticulum of the second portion of the duodenum.

Comment. Of the cases reported in this paper, this is the only instance in which the diagnosis of traction diverticulum is not confirmed by direct observation at surgery. However, it is thought that the persistent demonstration of a pouch which has not changed over a fourteen-month period and its occurring in an asymptomatic patient who is known to have dense periduodenal scarring warrants the diagnosis of traction diverticulum. The possibility that this represents a congenital duodenal diverticulum is discounted since it was not present at the time of the operative choledochoduodenostomy.

CASE V. P. B., a white male, aged forty. This patient has been followed in the medical outpatient clinic subsequent to an admission to Parkland Hospital in December, 1951, for myocardial infarction. In February, 1952, he began to complain of postprandial epigastric pain associated with belching and on February 25, 1953, an upper gastrointestinal study (Fig. 9*a*) was performed. This study was reported to show irregularity of the mucosal pattern over the greater curvature opposite the incisura of the stomach. The interpretation of the underlying cause of this deformity was deferred and it was requested that a re-examination be done. The complaints of burning and pain in the epigastrium persisted until antacids were prescribed and the discomfort was relieved. On April 9, 1952, a repeat roentgen examination of the upper gastrointestinal tract (Fig. 9*b*) again demonstrated the irregular rugal pattern of the greater curvature extending over a distance of 5 to 6 cm. It was observed at fluoroscopy that the deformity was accentuated by deep palpation and there was the impression of a central crater that was more pronounced by elevating the stomach. The patient continued to be asymptomatic on medical therapy and on April 14, 1952, a third upper gastrointestinal series was done (Fig. 9*c*). The irregularity along the greater curvature of the stomach had persisted and there appeared to be a definite central collection of barium in a pocket. The fluoroscopist's opin-

ion was that the pocket was extraluminal but roentgenographically it appeared to project to, but not beyond, the limits of the gastric lumen. No localized tenderness was elicited upon palpation over this area. A gastric analysis performed several days prior to the last roentgenographic study demonstrated no free acid from the fasting sample, but 18 degrees of combined acid. Histamine was given and forty-five minutes later free acid was 78 degrees, combined 86 degrees and total acidity 164 degrees. On April 22, 1952, exploratory laparotomy was performed. The following is a quotation from the operative record: " . . . upon opening the peritoneum, the omentum, transverse colon, gastrocolic omentum and stomach were delivered into the wound. On exploration of the stomach, no tumor, no ulcer, nor other identifiable lesion was found. Consequently, at the midportion of the stomach a transverse incision was made into the stomach and under direct visualization the entire mucosa of the stomach was explored and palpated. Again no lesion was found. A finger was inserted through the pylorus into the duodenum and no evidence of ulcer was found. The pylorus was patent. Following this, exploration of the serosal surface of the stomach on the anterior portion showed a thick fibrous band of scar tissue which extended from the midportion of the anterior serosal surface of the stomach inferiorly to the gastrocolic ligament; and when the omentum was replaced within the abdominal cavity, this band of fibrous tissue produced a diverticulum of the anterior portion of the stomach which was undoubtedly the deformity that was seen at the x-ray examination of the stomach previously. . . . "

Fig. 8. Case iv. Repeat gastrointestinal series after fourteen months' interval. The diverticulum is still evident. Note the change in contour, presumably the result of continued retraction of the extraduodenal scar tissue. This configuration typifies the traction diverticulum.

DISCUSSION

The differentiation of benign ulcers of the gastrointestinal tract and traction diverticula may be difficult. This is illustrated by the cases above in which the proper distinction was not made except eventually in Case iv. Undoubtedly, the roentgen interpretation was influenced by the past histories of ulcers in 2 of the patients and by the presence of portal hypertension (without demonstrable varices) in the third person; clinically and experimentally the incidence of benign ulcers is significantly increased by the presence of portal hypertension.[2] The history of previous perforations (Cases i and ii) suggested recurrent ulceration. However, this sequence of events which predisposes to the formation and contraction of dense adhesions that may lead to the development of traction diverticula should also have suggested the likelihood of their presence. In a patient with this history, who exhibits atypical symptoms and atypical roentgen features of benign ulcers, the presumptive diagnosis of traction diverticula must still be confirmed by definite roentgenologic criteria.

ROENTGEN FEATURES

Similar to a benign ulcer, the traction diverticulum is seen as a niche or pocket projecting beyond the limits of the lumen; the niche is regular in outline. At roentgenoscopy, the barium solution is retained in the crater and is not expressed by direct palpation or pressure; however, the pouch empties eventually and is not visualized on

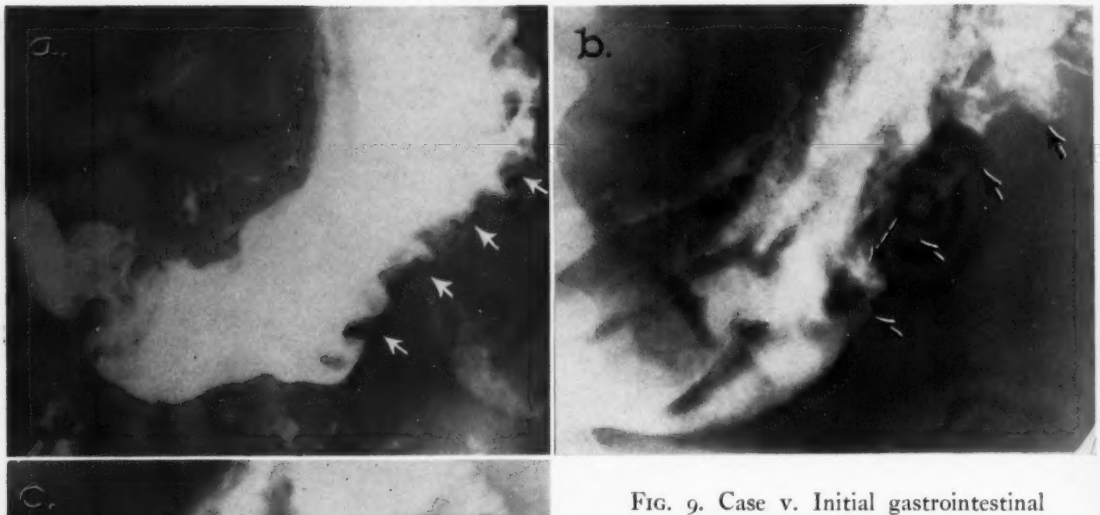

FIG. 9. Case V. Initial gastrointestinal series (Fig. 9*a*). Repeat gastrointestinal series performed six weeks (Fig. 9*b*) and seven weeks (Fig. 9*c*) later. Note the impression on the greater curvature (arrows) and the central pouch (dotted arrows) in Figures 9*b* and 9*c*. The diverticulation appears to be acquired over the interval of these examinations as a result of contraction of the scar tissue which was present on the initial examination. Even in retrospect, the diagnosis in this case could not have been made without operative confirmation.

roentgenograms taken two or more hours after drinking the opaque medium. Unlike benign ulcers, the extraluminal projection is more triangular in shape with a broad base and a blunt apex pointing outward (Fig. 1, 2, 3, 4, 7, and 8). The configuration and depth of the pouch may change slightly with the dynamics of palpation and peristalsis, and the contour may differ on successive examinations incident to the continued contraction of the scar tissue which is producing the pouch (Cases IV and V). Several other roentgen features of peptic ulceration are notably absent in and about the niche of a traction diverticulum. The overhanging edges seen in association with benign ulcers[1] are not demonstrated in any of the cases presented here. The collar that occurs about the base of ulcer craters is absent in each of the traction diverticula except in the duodenum of Case III (Fig. 5*a*, *b*, and *c*) in which a halo radiolucency circumscribing the lumen of the crater suggests marginal edema. This finding is evidently due to the cuff-like impression of the ring of scar tissue projecting into the lumen about the point of traction. A similar phenomenon is shown in Figure 9*c*. Radiation of the gastric rugae outward from the base of the craters was not a conspicuous feature in any instance. In Case III, this characteristic was suggested on the first examination (Fig. 5*d*), but a repeat gastrointestinal series using double contrast studies of the antrum dispelled the illusion of converging gastric folds (Fig. 6*a*, *b*, and *c*). A generalized gastritis was evident in two of the cases, but no localized edematous or hypertrophied rugal folds were seen about the niche bases. No in-

cisura on the wall opposing the niche was ever observed, and local tenderness was not elicited upon deep palpation of the craters. One may assume that the traction diverticula would persist essentially unchanged over a long period of time and would show no response to medical therapy. Case IV illustrates this point, and the constant pocket observed upon repeated roentgenologic examination over a period of fourteen months made less probable the initial diagnosis of benign ulceration. The radiologist is justified then, providing that the clinical status of the patient permits, in requesting repeated studies of the upper gastrointestinal tract when traction diverticula are suspected.

Briefly, traction diverticula may be recognized by the positive sign of a persistent localized outpouching which can be demonstrated repeatedly by serial films on successive roentgenologic examinations. The differential diagnosis is based largely upon *negative* clinical, roentgenoscopic, and roentgenographic findings, i.e., the absence of typical features one expects to be associated with true ulcers. The history of previous abdominal surgery or of a previous perforated ulcer is significant. Confirmation may be obtained by progress examinations which show no appreciable change in the pocket over a protracted period in spite of active medical therapy. The stability of the lesion is also contrary to what is observed in malignant ulceration. Although it is not within the scope of this paper to discuss the differential features of benign and malignant ulcers, it should be stated that the extraluminal pocket and associated roentgen findings produced by traction diverticula are dissimilar to ulceration in a neoplasm.

Congenital or acquired pulsion diverticula differ from traction diverticula in their location. In the stomach, diverticula other than the traction variety have a predisposition for developing in the cardia near the esophageal entrance.[4,6] In the duodenum the most common location is near the papilla of Vater.[5] None of the gastric or duodenal traction diverticula presented in this paper occurred in these sites of predilection. The roentgen features of congenital or acquired pulsion diverticula and traction diverticula also differ. As opposed to the traction type, other diverticula project farther beyond the wall of their origin and have a longer, narrow neck with a dilated outer end resembling a mushroom. Since the narrow neck impedes emptying, these diverticula may retain barium for many hours. The traction diverticula, being more shallow and having a broad base, empty more readily and do not retain barium for any protracted length of time.

SUMMARY

The entity of pseudo-ulceration of the stomach and duodenum produced by traction diverticula is described. The findings that permit the recognition of this abnormality and the positive and negative roentgen features that permit a differentiation from peptic ulcerations are discussed.

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BLOOD CLOT IN THE STOMACH SIMULATING NEOPLASM*

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PRIOR to 1936, the roentgen study of the gastrointestinal tract with contrast substances in the presence of massive upper gastrointestinal bleeding was felt to be a hazardous procedure, fraught with danger to the patient, and producing little of value of the clinician. Beginning with the work of Hampton,[2] and following with the studies of Thorstad,[5] Schatzki[4] and others, the roentgen technique established itself as a method of first importance in the evaluation of the patient bleeding from the gastrointestinal tract, even during the stage of active hemorrhage. The problem has been reviewed by Ritvo and his co-workers,[3] and a complete description of the exact roentgen technique employed by them is given.

The case described below illustrates a serious diagnostic pitfall encountered in the examination of an acutely bleeding patient—a massive blood clot simulating carcinoma of the stomach. The uniqueness of this case lies in the particular roentgenologic picture it presented. That blood in the stomach may occasionally be confused with a polypoid mass has been previously noted by Schatzki.[4] Gottlieb and his coworkers[1] have described the unusual case of a newborn infant in whom the perforation of a large gastric ulcer occurred, which presented roentgenographically with a massive pneumoperitoneum and a rounded, scalloped, cauliflower-like defect in the pars cardia of the stomach. Operation disclosed that this mass represented a huge blood clot which was overlying and plugging the ulcer crater in the stomach.

The usual appearance of blood within the stomach, however, is for all practical purposes indistinguishable from that of food. It consists of a mottled appearance within the lumen of the stomach where the blood and barium have intermixed. Since the particles of blood are not fixed, the filling defects produced by them are readily displaced and are changed in size and shape by altering the position of the patient, and by massage or manipulation under fluoroscopy (Fig. 1).

The case documented below is unusual in that the blood within the stomach apparently clotted and became adherent to the mucosa of the stomach. It thereby produced a constant, irregular filling defect, with a distinct, sharp edge, which failed to change position or character under fluoroscopic manipulation and which remained fixed in spite of change in position of the patient. It satisfied, therefore, all the roentgen criteria for neoplasm of the stomach except one: it disappeared on a second examination performed forty-eight hours later.

REPORT OF CASE

The patient, a sixty-five year old white Italian stonecutter, was admitted to Bellevue Hospital with the chief complaint of sudden vomiting of bright red blood. On the morning prior to admission, the patient experienced a "full feeling" within his abdomen, associated with nausea and vague epigastric distress. He did not eat, but took a dose of "English salts" and some black coffee. Immediately, he broke out into a profuse sweat and became quite weak. He developed profuse, bloody diarrhea, and vomited up large amounts of blood.

For the past year, the patient had fairly constant, not too severe, generalized abdominal pain which was occasionally relieved by milk. In this period of time, he lost 10 pounds.

The patient denied previous nausea or vomiting, anorexia, jaundice, melena, or hematemesis. He claimed that his alcoholic intake

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was limited to two glasses of wine taken daily with meals. He maintained that he ate a regular, balanced diet.

The patient presented as an elderly, somewhat emaciated white male, with a brownish cast to the skin. Physical examination was negative except for the palpation of a large mass in the abdomen, extending down to the umbilicus on the right, and extending over into the left upper quadrant. The edge was not clearly discernible, but was interpreted as nodular by some observers. The patient exhibited the vital signs of mild surgical shock, with a blood pressure of 90/55, a pulse of 98, respirations of 24, and a normal temperature.

His hospital stay was stormy, and his bleeding continued unabated for ten days. Daily values of hemoglobin in grams (Sahli) were: 12.0, 10.5, 8.0, 8.5, 8.5, 8.5, 7.0, 6.0, 6.5, 6.5, 8.0, 7.0, and 8.0. The red blood count was taken on four different occasions, and was 3,600,000, 2,590,000, 1,980,000 and 2,710,000 cells. The serology was negative, and repeat urinalyses were normal. The non-protein nitrogen of the blood was 56 mg. per cent, and reverted back to 28 mg. per cent on the fourteenth hospital day. The A/G ratio was 3.4/2.2, the cholesterol and esters were 136/79, the icteric index was 12 units, the cephalin flocculation was 0, and the alkaline phosphatase was 9.4 Bodanksy units. Eight pints of blood were required to finally stabilize the patient's hemoglobin at 8.0 gm. on the tenth hospital day.

Fig. 1. A proved case of carcinoma of the antrum of the stomach in the presence of massive upper gastrointestinal hemorrhage. Note the characteristic mottled appearance within the lumen of the stomach, produced by the admixture of blood and barium.

Fig. 2. Note the sharply defined filling defect on the greater curvature of the stomach, pars media. It did not alter its size or shape in spite of fluoroscopic manipulation and change in position of the patient. It was felt to represent carcinoma.

On the sixth hospital day, the first gastrointestinal series was performed. The patient had received nothing by mouth for the previous week.

Fluoroscopically, a large mass was immediately noted on the greater curvature of the stomach which remained fixed in position in spite of gentle manipulation, and which did not alter in character with variation in position of the patient. Multiple regular and spot films of this area were taken, and the official report from the Department of Roentgenology was: "Extensive irregular greater curvature filling defect of the stomach indicating neoplastic disease" (Fig. 2). The esophagram was interpreted as negative.

A repeat examination was ordered two days later (Fig. 3). On this second examination, there was no evidence of the large irregular

FIG. 3. Repeat examination forty-eight hours later, same case as Figure 2. The "tumor" has vanished. The greater curvature of the stomach presents a smooth, rounded contour, and good peristaltic activity is present.

filling defect previously noted on the greater curvature of the stomach. The greater curvature instead revealed a smooth, regular, flexible outline, with evidence of good peristalsis under fluoroscopy. Gastroscopy was performed on the ninth hospital day, and no evidence of pathology on the greater curvature was noted. Esophagoscopy was performed on the fifteenth hospital day, and the esophagoscope passed with ease all the way into the stomach. No intrinsic lesion of the esophagus was noted.

On the twenty-third hospital day a liver biopsy was done and the liver was described as hard and scratchy under the needle, but the tissue obtained was insufficient for diagnosis. The patient signed out, against advice, the following day.

Restudy of all the films by the radiologists convinced them that a small lesion at the cardia of the stomach had been overlooked, and an unsuccessful effort was made to locate the patient to have him return for further studies.

Two months later the patient voluntarily re-

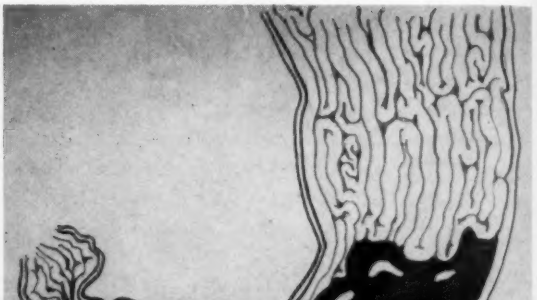

FIG. 4. Tracing of Figure 2 to demonstrate graphically how an adherent blood clot in the stomach could produce a filling defect closely simulating neoplasm.

turned to the hospital, in terminal state, with a renewed attack of massive bleeding. He expired shortly after admission before workup could be undertaken, as a result of exsanguination. Autopsy disclosed: *cirrhosis of the liver* and *esophageal varices*. The stomach was intrinsically normal.

COMMENT

This patient had nothing by mouth for six days prior to roentgen examination. An irregular filling defect was noted on the greater curvature pars media which was erroneously interpreted as neoplasm. Two days later a repeat gastrointestinal series was performed, and the previously noted tumor mass had disappeared. Gastroscopy confirmed the absence of this mass, and an autopsy performed two months later proved the stomach to be intrinsically normal. In view of the fact that the patient experienced massive hemorrhage prior to examination and that he had nothing by mouth for six days, we feel it is a fair assumption to maintain that blood clot was responsible for the "vanishing tumor." The confusing and interesting feature of this case is the sessile tumor mass simulated by this blood clot. The intraluminal mottling which changes in position and

character gives the roentgenologist little difficulty in diagnosis; but a fixed tumor mass, which is invariable in position and cannot be dislodged by manipulation, represents a picture indistinguishable from carcinoma and suggests a rather firm clot which has temporarily become adherent to the mucosal lining of the stomach. Considering the frequency with which roentgen examinations are now being performed in the presence of active bleeding, it is surprising to find only one previous report in the literature documenting findings similar to our own. What factors prompted the development of this type of adherent blood clot in this case, or why it so rarely occurs in the usual case, we are unable to say.

Since gastrointestinal roentgen-ray examinations are now being performed with increasing frequency in cases with massive upper gastrointestinal bleeding, we feel it is wise to stress that any tentative diagnosis of carcinoma of the stomach be subjected to re-examination at a later date, in order to prevent the mis-diagnosis of blood clot as carcinoma. Our own case demonstrates the practical value of the repeat examination, since a potentially correctible lesion was uncovered which was overshadowed by the "vanishing tumor," and which might have resulted in saving the life of the patient, had appropriate therapy been undertaken.

SUMMARY

1. A case of upper gastrointestinal bleeding is presented in which a blood clot in the stomach presented roentgenological features indistinguishable from that of carcinoma, but which disappeared on a subsequent examination forty-eight hours later. The patient proved on autopsy to have had esophageal varices.

2. The importance of repeat confirmatory roentgen examinations in all cases diagnosed as carcinoma of the stomach in the presence of active bleeding is stressed.

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BENIGN ULCERATION ON THE GREATER CURVATURE OF THE STOMACH*

REPORT OF SEVEN PROVED CASES

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BENIGN ulcers on the greater curvature of the stomach have been considered extremely rare. In a critical review of the literature in 1931, Sproull[21] was able to find only 10 cases with a well substantiated histologic diagnosis. Matthews'[14] painstaking review of the literature in 1935 revealed only 22 proved cases. In a recent review, Friedman and Epstein[7] were able to find only 24 cases in which the diagnosis was conclusive and they reported 2 cases. Other recent articles, reporting 1 or 2 cases, indicate the rarity of the condition,[1–4,6,8–10,13,22] Moreover, none of the participants in an extended panel discussion concerning gastric ulcer and carcinoma held in 1949[17] reported having seen more than 2 cases of benign ulcer on the greater curvature.

Recently, however, evidence has been increasing that benign gastric ulcers are not as rare as previously thought. Thus, Lahey, who stated in 1943 that he had never seen such a lesion,[11] had encountered 6 by 1952.[12] Palmer,[18] who personally studied 100 cases of small benign gastric ulcer, found 9 per cent on the greater curvature, all proved by histologic study following gastric resection. A 1953 report by Silk, Blomquist and Schindler[19] mentioned 8 cases confirmed by microscopic study. An analysis by Smith and co-workers[20] of 1,000 cases of gastric ulcer at the Lahey Clinic published in 1954 indicated that 17 of the 451 resected benign gastric ulcers were demonstrated roentgenologically to be on the greater curvature, only 4 of which were thus described by the pathologist. McGlone and Robertson[15] reported 7 of 300 benign ulcers on the greater curvature. Among 160,000 consecutive new patients studied at the Ochsner Clinic and Ochsner Foundation Hospital, a diagnosis of benign gastric ulcer was made with considerable certainty in 244, in 148 of which the diagnosis was microscopically verified. Of the latter 148 cases, 7 were on the greater curvature, or an incidence of 5 per cent. Thus, the reported incidence in recent years has ranged from 1 to 9 per cent. The 7 cases, which will be briefly described here, were encountered between 1948 and 1954.

REPORT OF CASES

CASE I. F.R., aged sixty-two years, came to the Clinic because of known hypertension for one year, and recent nervousness and anxiety. He had also noted some indigestion and epigastric pain. In the preceding two months he had lost 25 pounds in weight. Blood pressure was 190 mm. Hg systolic, 140 mm. Hg diastolic. Gastric analysis revealed free acid, 100 degrees; total, 110 degrees. Roentgenologic examination disclosed a prepyloric deformity of the stomach with an apparent filling defect in the antrum, mucosal irregularity and some narrowing and stiffness in the prepyloric area (Fig. 1). On re-examination six days later, less stiffening of the gastric wall was noted and the lesion was thought to be benign.

At subtotal gastrectomy eight days later, the ulcer was seen to be on the greater curvature and anterior wall in the prepyloric portion of the stomach. Pathologic study showed a benign gastric ulcer with associated chronic gastritis. The patient was discharged from the hospital in good health, except for the cardiac disease. He died about three and one half years later of sudden massive coronary occlusion.

CASE II. H.M., aged eighty-two years, was admitted to Ochsner Foundation Hospital for treatment of a clavicular fracture. He gave a history of indigestion and epigastric pain of

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six months' duration. The sedimentation rate was 69 mm./hr. (Westergren). Radiologic examination showed a 4 cm. area of the gastric antrum to be irregular, rigid and devoid of peristalsis (Fig. 2). There was equivocal evidence of a filling defect in the antrum and the mucosal folds of the stomach were enlarged. The radiologist favored a diagnosis of gastric carcinoma. Seven days following admission subtotal gastrectomy was done. The excised stomach contained a 3 cm. irregular prepyloric ulceration on the greater curvature. The ulcer had rolled edges and was 8 mm. deep; grossly, it was thought to be carcinoma. Microscopic diagnosis was benign gastric ulcer. When last examined the patient was well.

Case III. R.S., aged sixty-three years, was admitted to Ochsner Foundation Hospital because of intermittent episodes of epigastric pain, associated with nausea, vomiting, anorexia, and recent weight loss of 15 pounds. On physical examination the patient appeared pale and chronically ill. Occult blood (2 plus) was found in the stools. Roentgenograms of the stomach, made elsewhere two weeks previously, were interpreted as showing antral deformity and narrowing with some obstruction. Roentgenologic examination showed pre-

Fig. 1. Case I. Roentgenogram showing benign gastric ulcer on greater curvature side of prepyloric area.

Fig. 2. Case II. Roentgenogram showing deformity from benign ulceration on greater curvature of antrum of stomach.

pyloric narrowing, with evidence of partial obstruction and some mucosal change. The radiologist favored a diagnosis of scirrhous carcinoma. Subtotal gastrectomy was done promptly. The excised specimen had an antral greater curvature and posterior wall ulcer which measured 2.3 by 1.0 cm.; it was 3 mm. deep. A histologic diagnosis of benign gastric ulcer was made.

On the eighth postoperative day, the patient had a febrile episode with accompanying abdominal pain and tenderness, which was considered to be the result of leakage at the suture line with localized abscess formation but it responded favorably to medical treatment. The patient was discharged on the fourteenth postoperative day. Except for development of an abdominal abscess which required drainage he has remained well.

Case IV. J.J., aged fifty-three years, was admitted to Ochsner Foundation Hospital with a history of nervousness, headaches and abdominal pain for at least eighteen months. He had noticed anorexia and had lost 20 pounds in weight. Moderate abdominal tenderness was present. Previously he had been admitted to another hospital because of an episode of coronary occlusion. A diagnosis of gastric ulcer

Fig. 3. Case iv. Roentgenogram showing large benign ulcer on greater curvature opposite the angle of the stomach.

had also been made at that time, following roentgenologic examination of the stomach.

Gastric analysis revealed free acid, 35 degrees; total, 48 degrees. Roentgenologic examination showed an ulcer crater on the greater curvature of the stomach opposite the angle (Fig. 3). The ulcer was 1.5 cm. in diameter, was inset in the gastric outline, and appeared to have a radiolucent halo around it (meniscus sign). The radiologist favored a diagnosis of malignant ulcer. On gastroscopic examination the ulcer was not visualized.

At subtotal gastrectomy four days after admission the lesion appeared benign. The resected stomach contained two ulcers; the one on the greater curvature measured 2 cm. in greatest diameter and another shallow ulcer on the prepyloric lesser curvature measured 1.3 cm. The microscopic diagnosis of both lesions was chronic peptic ulcer. The patient has remained well since operation, except for tension headaches.

Case v. N. G., aged thirty-four years, was admitted to Ochsner Foundation Hospital with a long history of complaints. Roentgenologic study at the age of thirteen years was said to have shown a narrowed outlet of the stomach. Indigestion, epigastric pain, nausea, vomiting and anorexia had become noticeably worse in the year preceding admission. He had lost 10 pounds in weight during the preceding months. Only nervousness and tension were apparent on physical examination. The sedimentation rate was 8 mm./hr. (Westergren). Gastric analysis revealed free acid, 3 degrees; total, 8 degrees. Roentgenologic examination showed a deformity of the greater curvature of the gastric antrum, with a tender out-pocketing which resembled an ulcer crater. Exaggerated mucosal folds radiated toward the lesion (Fig. 4). The radiologist thought there was an ulcer on the greater curvature. Examination one week later showed slight decrease in size of the ulcer. It was not seen during gastroscopic examination.

Five days after admission subtotal gastrectomy was done. In the resected stomach was a 1.6 cm. ulcer on the greater curvature, with indurated and elevated margins. Grossly, it resembled a neoplasm. Microscopic diagnosis was active peptic ulcer. There was no evidence of carcinoma in the ulcer or lymph nodes. The patient has remained in good health.

Case vi. W. H., aged fifty-four years, was

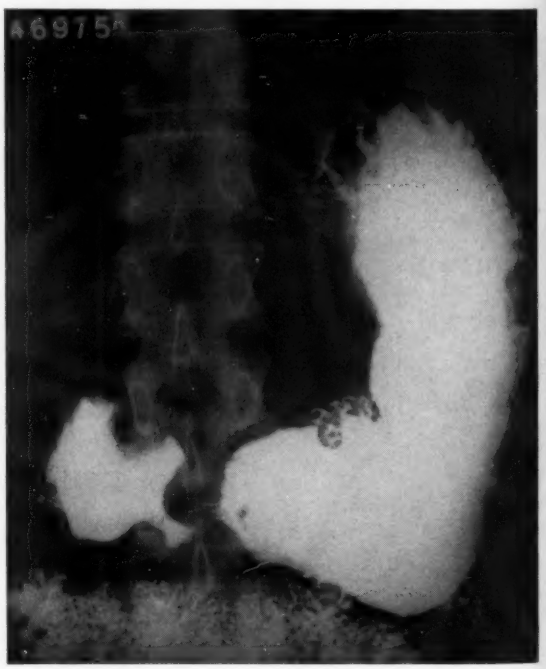

Fig. 4. Case v. Roentgenogram showing benign gastric ulcer involving prepyloric portion of the stomach.

admitted to Ochsner Foundation Hospital because of abdominal pain and nausea of three months' duration. He had lost 15 pounds recently and complained of some indigestion and weakness. The abdomen was moderately tender and a palpable mass was noted in the epigastrium. The white blood count was 18,000 per cu. mm. and the sedimentation rate was 60 mm./hr. (Westergren); occult blood (4 plus) was found in the stool. Roentgenologic study showed a large gastric ulcer on the greater curvature of the mid-portion of the body of the stomach. The huge penetrating crater extended onto the posterior wall and posteriorly. The ulceration measured 4 cm. across the base and was 3 cm. deep. The radiologist favored a diagnosis of malignant ulcer (Fig. 5). Medical treatment for a week resulted in no decrease in size of the ulcer, as shown by roentgenologic re-examination.

Twelve days after admission subtotal gastrectomy was done. Pathologic examination showed an active penetrating peptic ulcer on the posterior wall and greater curvature of the stomach. The ulcer measured 3.5 cm. in diameter and there was no histologic evidence of malignancy. The patient was discharged from the hospital in good condition and has remained well.

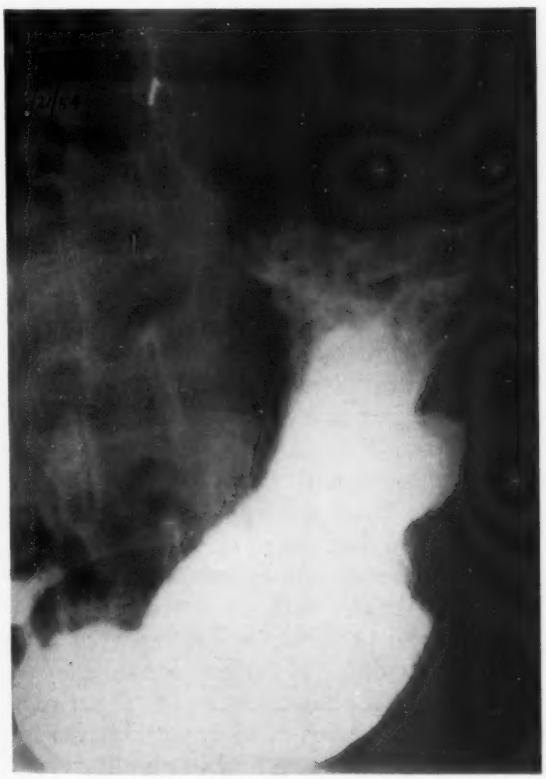

Fig. 5. Case vi. Roentgenogram showing huge benign ulcer, involving greater curvature and penetrating posteriorly.

Fig. 6. Case vii. Roentgenogram showing benign gastric ulcer, located high on the greater curvature of the stomach.

Case vii. Mrs. W. C., aged sixty-three years, was admitted to Ochsner Foundation Hospital complaining of nausea and pain in the epigastrium and right upper abdominal quadrant, which had been constant for two weeks. Epigastric tenderness was present. The sedimentation rate was 75 mm./hr. (Westergren). Gastric analysis revealed free acid, 11 degrees; total, 21 degrees. Roentgenologic examination disclosed a 2 cm. ulcer on the greater curvature of the body of the stomach (Fig. 6).

The ulcer was visualized by gastroscopic examination preceding surgical excision one week following admission. The gastroscopist, the surgeon, and the pathologist thought the ulcer appeared to be malignant. It was a 2 cm. lesion, with firm raised borders, on the greater curvature. The final microscopic diagnosis by several pathologists was chronic gastric ulcer with considerable chronic inflammatory re-

action. The patient recovered promptly and has remained in good health.

DISCUSSION

The differing statistics on ulceration of the greater curvature of the stomach undoubtedly result from a difference in concept as to what constitutes greater curvature localization. The primary criterion used in this report was the roentgenographic appearance of the stomach in the posteroanterior projection. In this projection the lesion must occupy a position on the left or the inferior profile of the barium-filled stomach. Of necessity, a large ulcer must extend onto the anterior or posterior wall of the stomach. This was apparent in the largest of the ulcers in our patients (Case VI); in this case the lesion penetrated posteriorly and involved the posterior wall as well as the greater curvature. Careful fluoroscopic study of the stomach with the patient in various positions and in varying degrees of rotation, as well as roentgenograms made in different projections, should enable the radiologist to state with assurance in most cases whether the greater curvature is the site of ulceration.

Usually the surgical report confirms the roentgenologic demonstration of the site of ulceration, the line of attachment of the greater omentum generally being the point of reference. As Palmer[18] pointed out, the mesenteric attachment and the roentgenologic profile may not coincide exactly. Sometimes the exact site of ulceration is not mentioned in the surgical report, and at times even the gross description of the surgical specimen in the pathologic report may be incomplete. It therefore seems justifiable to depend greatly on the roentgenograms as the final arbiter of localization. The roentgenograms must be of good quality, the ulcer clearly apparent, and the stomach in normal position without gross distortion or deformity. Under such circumstances, localization is generally above dispute. Needless to say, great weight is given to accurate descriptions by the surgeon or pathologist.

In the cases herein presented, the surgical reports specifically mentioned localization on the greater curvature in 5 cases. In Case II the surgical report mentioned only a "mass in the gastric antrum," but the gross description of the excised specimen clearly indicated an ulcer on the greater curvature. In Case VI a posteriorly penetrating ulcer was mentioned in the surgical report, and in the pathologic gross description the lesion was described as chiefly on the posterior wall. The roentgenograms indicated that the greater curvature was involved by at least part of the large ulcer.

Adequate demonstration of a benign ulcer on the greater curvature of the stomach demands conscientious fluoroscopy and precise technical skill in making the roentgenogram as Campbell[3] emphasized when he wrote, "with careful technique the mucosa can be shown to be intact up to the ulcer margin." Unusually prominent mucosal folds are occasionally seen along the greater curvature and may mimic gastric ulcer. These are usually multiple, can be "ironed out" by palpation during fluoroscopy, and tend to flatten out as the stomach is filled with barium mixture. Gastric carcinoma, of course, is the prime consideration in differential diagnosis An associated fungating filling defect, loss of flexibility of the gastric wall adjacent to the ulcer, distortion of the surrounding mucosa, and irregularity of the ulcer crater suggest a neoplasm rather than a simple ulcer.[16]

As a clinical entity, gastric ulcers represent more than the complex problem of differential diagnosis of benign versus malignant lesion. As Palmer[18] pointed out, one must reckon with the features of hemorrhage and perforation. He reported a 12 per cent incidence of perforations and Feldman[5] reported an incidence of 17.6 per cent in a collected series of 68 greater curvature ulcers he was able to find in the literature up to 1954.

The value of alert fluoroscopy, of careful mucosal study before the stomach is

over filled with barium mixture, and of compression spot films of the ulcer cannot be stressed too strongly. Especially is this true if smaller lesions are to be identified.

Despite the fact that increasing numbers of these benign ulcers on the greater curvature are being reported, it bears repeating that malignant ulcers are much more common on the greater curvature. It would therefore seem wise to consider gastric resection promptly in all cases.

SUMMARY

Seven cases of benign gastric ulcer on the greater curvature of the stomach are reported. They constituted 5 per cent of the benign ulcers in a series of 148 surgically resected and microscopically verified gastric ulcers. Recent reports suggest that benign ulceration on the greater curvature of the stomach may not be as rare as previously considered.

Adequate roentgenologic examination is the most available, the easiest, and probably the most accurate method of diagnosis. Alert fluoroscopy, careful mucosal study, and compression spot films are integral features of the examination. Although recognizing that benign ulceration may occasionally be present on the greater curvature, the radiologist and clinician both must remain aware of the much higher incidence of malignant lesions in this portion of the stomach.

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BENIGN AND MALIGNANT ULCERS OF THE GREATER CURVATURE OF THE STOMACH

A STUDY OF 8 CASES, 6 PROVED BENIGN*

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THE recent occurrence of several consecutive cases of benign ulcer of the greater curvature of the stomach at Hines Hospital caused me to wonder whether this condition is really as rare as it is generally considered to be. In an attempt to answer this question, the experience at this hospital in the past five years was reviewed.

All the proved cases of gastric ulcer in this period were studied, with review of the roentgenograms, and with confirmation of the location and benignancy by surgery or postmortem examination. In this group, there were 6 cases of benign ulcer of the greater curvature of the stomach. For the same period, with the aid of the Tumor Research Unit, the records of all the proved cases of gastric carcinoma (there were 251 of these) and sarcoma (10 cases) were reviewed. This was done to find out if any of these cases were greater curvature lesions, considered on roentgenographic examination to be a variety of ulcer. There were 2 cases of this kind. Excluded from consideration here were cases showing ulceration with grossly recognizable tumor. Our clinical material, then, to be discussed in detail later, consists of 8 cases of ulcerative lesions of the greater curvature of the stomach. Six of the 8 cases were found to be benign ulcers, 2 were malignant.

This distribution, so different from what might have been expected, stimulated me to read further the literature on this subject, and to learn what I could from our own cases, as well as those of other writers.

Certain ideas about gastric ulcers, which have had a great influence on all of us, have had to be considerably modified or abandoned as a result of experience. For instance, in previous years, we frequently heard a dictum concerning the size of gastric ulcers in relation to their being malignant. It was stated as follows by MacCarty[16] in 1940: "I am quite certain that at least 90 per cent of all chronic gastric ulcers larger than a quarter (2.5 cm. in diameter) are definitely cancers." This opinion was echoed by Russell[22] and others. Yet, at a panel discussion[19] on the relationship of gastric ulcer to cancer, three eminent authorities (Stout, Benedict, and Comfort) stated that almost every ulcerative lesion of the stomach greater than 4 cm. in diameter is carcinoma; three other eminent authorities (Sussman, Golden, and Jordan) denied that the size of the crater had any relation to its malignancy or benignancy. This dictum, in fact, no longer enjoys authoritative status.[12,26]

The idea that the location of a gastric ulcer may be an important factor in the diagnosis of malignancy has gained wide acceptance. Allen[1] said that "nearly all" ulcers of the greater curvature and fundus are carcinoma. Holmes and Hampton,[11] who in their own article did not analyze their cases as to location, nevertheless stated that surgery is indicated in all chronic indurated ulcerating lesions of the greater curvature of the stomach. They also published a diagram, in which certain parts of the stomach (antrum and greater curvature) were labelled malignant, and the lesser curvature was labelled benign. Lewis Gregory Cole, commenting on this paper, said that if those statements were accepted as the prime factor, it would set

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back the science of roentgen diagnosis of gastric lesions by nearly two decades.

Sproull[25] reported a single case of ulcer of the greater curvature which he had considered benign on roentgen examination and was also thought by the surgeon and the pathologist to be grossly benign, but was found on histologic examination to be a carcinoma. However, all three roentgenograms reproduced in his article show that the ulcer crater was within a filling defect (which Sproull considered to be spasm). Also, there was no change in the gastric lesion on three roentgen examinations in a period of six months. And yet, on the basis of this single case, which on review could be considered roentgenologically malignant, the author made this rather sweeping statement: "it is probably unwise for a roentgenologist to diagnose a greater curvature lesion as benign peptic ulcer—his chance of being right is very small, probably one in a million." This dictum, quoted by Russell[22] and others[24] has had considerable influence. So much so, that one sees in the literature many case reports[4,7,8,9,10,14,15,21,22] of a single case (or 2) of benign greater curvature ulcer, with emphasis on its rarity, but without any statement as to the number of malignant cases of ulcer in this location found by the same authors.

Smith and Jordan[24] found that 3 of their 47 cases of proved malignant gastric ulcers were on the greater curvature, and 2 of their 211 cases of proved benign ulcers were in the same location. They concluded that 60 per cent of their 5 cases of gastric greater curvature ulcers were malignant. To a radiologist their paper, which covers a great deal of ground, is somewhat lacking in detail, because they do not show the roentgenograms, or discuss roentgenologic data from which one might determine the presence of gross stigmata of malignancy in the films. In the diagrams summarizing their findings, the fundus and antrum appear to be excluded from the greater curvature. If, as Palmer[18] does, they considered the greater curvature to extend from the fundus to the pylorus, they would have had a larger number of cases of ulcer in this region, and a different percentage of malignancy.

Bowers and Rivers[6] studying 120 cases of benign ulcers and 120 malignant ulcers, found 4 ulcers on the greater curvature. All of the 4 were malignant.

Horn and Ravdin,[12] in a review of 193 cases of gastric ulcer and gastric carcinoma said that all cases of gastric greater curvature ulcers should be considered malignant from the start. Actually, 61 per cent of their greater curvature ulcers were benign (8 cases). In 52 cases in which they diagnosed carcinoma preoperatively, only 37 per cent had carcinoma. Of these 52 cases, 25 were benign ulcer, some of these being greater curvature ulcer.

Boudreau and his associates,[5] who studied benign and malignant gastric ulcers found at autopsy, showed that, of the benign group, 14 per cent were on the greater curvature, whereas 27 per cent of the malignant ulcers were in that location. Of all the greater curvature lesions in this series, 51 per cent were benign.

In a recent article, Silk, Blomquist, and Schindler[23] reported 18 cases of greater curvature ulcer, of which 8 were benign. In McGlone and Robertson's series,[17] there were 16 ulcerative lesions of the greater curvature of the stomach. These were all resected. Seven were proved benign (44 per cent).

In a recent textbook[21] the contradictory ideas now current about this condition are faithfully reflected. The authors begin by quoting Sproull's statement[25] that "the chances" of an ulcer of the greater curvature being benign are "probably one in a million." They show photographs of two histologically proved cases of their own, and say that many proved cases have been recently recorded in the literature. They advise the radiologist to "place reliance on the diagnostic criteria which in his experience has proved reliable and discard many of the ideas which have become accepted through frequent repetition, but have not

FIG. 1. (9,965 g). Case 1. J.M. Benign ulcer. See the projection of the crater beyond the luminal contour, and the radiating folds at the base of the ulcer. This ulcer was not seen gastroscopically.

withstood the test of scientific investigation."

REPORT OF CASES

[The first 4 of these cases have been reported by Baker and Gattas.[3]]

CASE 1. J. M., R# 320 939. A fifty-four year old white man with a history of vomiting episodes for years, especially in the past week. He had vomited blood in the week before admission, and occasionally before that. He had lost 30 pounds weight. He had been treated by a private physician for coronary disease and arthritis. On examination, he was a well developed and nourished man. His blood pressure was 150/100, his pulse 96. There was slight tenderness in the right upper quadrant of the abdomen. Laboratory data: 4.4 million red blood cells, 13 grams hemoglobin, 12,000 white blood cells with normal differential count. No gastric analysis was done. Chest roentgenograms showed slight cardiac enlargement. Gastrointestinal series (5-6-52) showed a collection of barium on the greater curvature in the antrum, which had the appearance of a large ulcer. There were radiating folds at the base of the ulcer (Fig. 1). The roentgen impression was: Large ulcer of the greater curvature of antrum, presumably malignant. Gastroscopy was reported as follows (5-15-52): "No crater was visualized, but on the greater curvature of the stomach proximal to the antrum, grayish opaque mucus was seen coming down from the posterior wall of the stomach. In view of the roentgenologic findings, a crater is probably situated on the posterior wall of the stomach which explains its non-visualization. The absence of blood in the gastric contents and lack of infiltration of stomach wall suggests that it is benign in spite of its apparent location on greater curvature." At operation (5-22-52), there was an extensive ulcer on the greater curvature of the stomach at the junction of the distal and middle thirds. There was no evidence of metastases. A subtotal gastrectomy was done. Pathologist's report: "The specimen is a portion of stomach measuring 13.5 cm. on greater curvature, 11 cm. on lesser curvature. An ulcer is present on the greater curvature. It measures 2.3 cm. in diameter. There is some induration about the ulcer. The ulcer penetrates all layers on the stomach (Fig. 2). Microsection shows wall of stomach. At one point, the mucosa ends, and is replaced by fibrous ulcer base. There is some small round cell infiltration in the base, and some exudate of debris on the surface. Diagnosis: chronic ulcer."

This patient was discharged after an un-

FIG. 2. (9,975a). Case 1. Resected portion of stomach. This photograph shows the radiating folds going to the base of the ulcer, noted in the roentgenogram (Fig. 1).

eventful recovery from his operation, and improvement of the cardiac disease as a result of therapy, 6-19-52. Re-examination 9-8-52 was because of symptoms of vomiting and loss of 6½ pounds weight since his discharge, believed to be due to poor diet. Gastrointestinal series at this time showed evidence of subtotal gastrectomy, and no evidence of recurrent disease. He was discharged improved 10-22-52. On follow-up examination, ten months after operation, there was no weight loss, vomiting or other complaint. Gastrointestinal series at that time showed no evidence of recurrent ulcer or malignancy.

Comment. In this case, the roentgen impression was ulcer, presumably malignant, in spite of the radiating folds at the base of the ulcer, and the projection of the crater beyond the gastric border. It was "presumed malignant," apparently because of its location on the greater curvature.

Case II. L. Mc A., R# 312 168. A forty-four year old white nurse who had been previously admitted to this hospital five years ago and again three years ago for treatment of symptoms diagnosed as due to duodenal ulcer. She had been admitted again three months ago for similar symptoms, but roentgen examination was negative for evidence of ulcer. On this admission, there was complaint of cramping pain in the left upper quadrant, commonly at night. Examination showed diffuse left epigastric tenderness, but was otherwise essentially negative. The gastric analysis showed no free acid, 50 units total acidity. Laboratory findings were otherwise unimportant. Gastrointestinal series (1-8-52) showed a large deep ulcer on the greater curvature in the antral area, with thickened mucosa in its neighborhood. The ulcer was considered malignant (Fig. 3). Gastroscopy on 1-9-52 and again on 1-22-52 (by different examiners) failed to visualize an ulcer crater, but on one examination, there was a prominent fold on the posterior wall of the antrum, possibly due to adhesions. On 1-26-52, operation was done. There was a prepyloric gastric ulcer involving the greater curvature and posterior surface, invading the pancreas, and involving the midcolic vessels in an inflammatory process. A Pólya subtotal gastrectomy was done. Pathological report: "The specimen consists of a segment of the stomach previously opened. In the distal third is seen a firm, rubbery, ulcerated area measuring 1.5×1 cm. It extends almost through the entire thickness of the wall. Histology: the ulcer extends to the deeper portions of the muscularis, sharply demarcated from the mucosa. The bed of the ulcer is composed of a layer of exudate, underneath which is a layer of fibrinoid necrosis and fibrosis (Fig. 4). Lymph nodes taken from the region show merely hyperplasia. Pathological diagnosis: Peptic ulcer of the stomach." Postoperatively, the patient developed a urinary tract infection, which responded well to treatment. She was discharged 2-20-52, free of synptoms.

Fig. 3. (9,427a). Case II. L.M. Benign ulcer. There is induration with altered mucosa near the base of the ulcer. On this basis a roentgen impression of malignancy seemed justified. This ulcer was not seen gastroscopically.

Gastrointestinal series fifteen months postoperatively was negative for recurrent disease of the stomach. The patient at this time was working, but had symptoms, including some weight loss, attributed to "dumping syndrome."

Comment. In this case, malignancy was suspected because of the thickened mucosal folds adjacent to the crater on the roent-

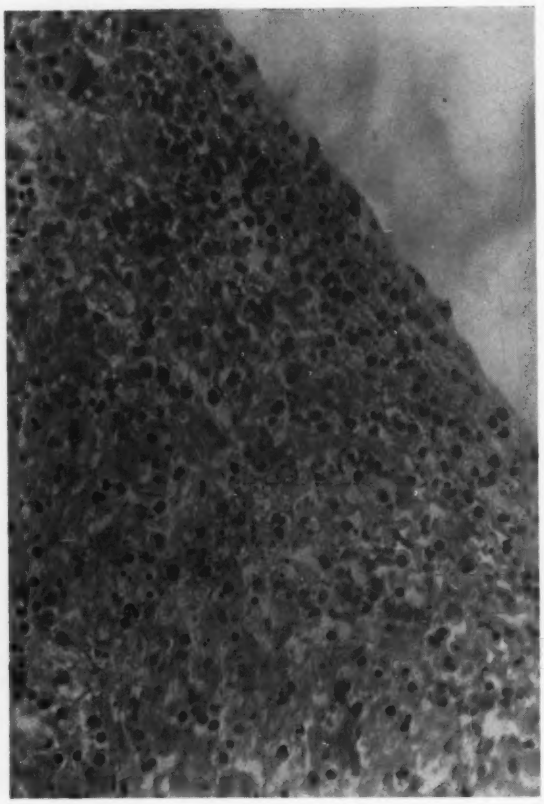

FIG. 4. (9,427i) Case II. The base of the ulcer consists of fibrin and necrotic cells. Below the necrotic debris is an extensive layer of granulation tissue with many fibroblasts and a moderate number of lymphocytes and eosinophils. The granulation tissue has numerous small capillaries. At one area the ulcer extends deeply and with a considerable amount of necrotic tissue. At the edge of the ulcer there is a thin layer of mucosa consisting of distorted acini. Beneath the mucosa is an extensive layer of dense fibrous tissue and smooth muscle.

genograms, and the location. However, it was actually a benign ulcer.

CASE III. B. S., R# 244 417. This forty year old white man was admitted to Hines Hospital 5-24-49, complaining of intermittent mid-abdominal pain and pain in the left tonsil. He had previously been treated at this hospital by external and interstitial irradiation, for squamous cell carcinoma of the base of the tongue, with extension to the cervical lymph nodes. Examination revealed a poorly nourished man who had a large mass in the left cervical lymph nodes, and evidence of carcinoma of the base of the tongue. There was postirradiation reaction of the skin of the neck. Laboratory examination showed several stools containing occult blood. Blood counts showed the presence of secondary anemia. Gastrointestinal series 5-18-49 revealed an ulcer niche on the greater curvature of the antrum (Fig. 5). The niche did not project beyond the contour of the stomach. On 6-4-49, the ulcer was still present and there was a slight filling defect around it. This, and the ulcer's location, suggested malignancy. The ulcer was still visible on 6-24-49. Gastroscopy was not done because of the presence of carcinoma of the tongue. Gastric resection was performed on 7-21-49. Pathological report: "The specimen showed an ulcer 0.4 cm. in diameter. The rugae appeared normal. Cut section through the ulcer revealed a thickened wall. Microsection showed a sharply punched-out ulcer in the stomach wall. The ulcer base was lined by inflammatory debris. The underlying tissue was predominantly

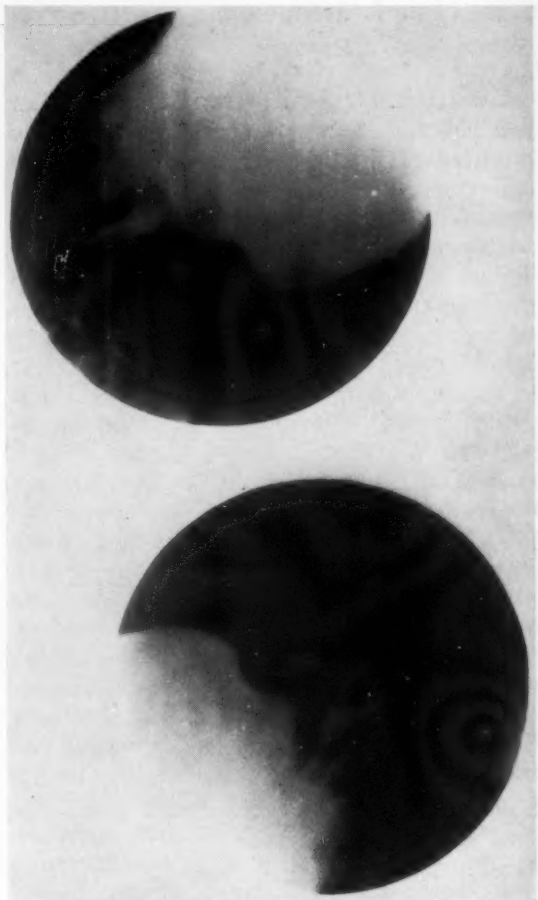

FIG. 5. (6,187) Case III. B.S. Benign ulcer. The ulcer seems to lie within a filling defect.

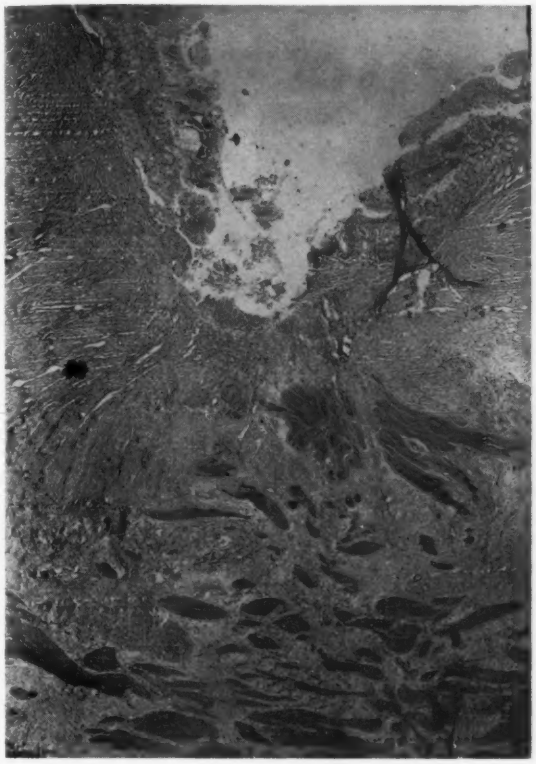

Fig. 6. (6,187c) Case III. The picture shows a small ulcer. The base of the ulcer has a small amount of granulation tissue with large vascular spaces. The adjacent mucosa is thin and atrophic. Beneath the mucosa is a considerable amount of fibrous tissue. Dense masses of fibrous tissue extend into the muscularis and separate the muscle into small irregular bundles.

fibrotic, and there was infiltration with chronic inflammatory disease (Fig. 6). There was no evidence of malignancy." The patient made an uneventful recovery from surgery, and was discharged 8-13-49. He was re-admitted 8-31-49 because of a painful tumor in the left side of the neck. The chest film showed evidence of far advanced bilateral pulmonary tuberculosis with cavitation. He was unable to retain anything by mouth. His condition became rapidly worse, and he died on 9-20-52. There was no autopsy.

Case IV, W. D., R# 203 259. This fifty-five year old white man was transferred to Hines Hospital 1-29-48, from another hospital. He complained of soreness of the tongue. A biopsy of the tongue lesion at the other hospital revealed squamous cell carcinoma. There were also episodes of epigastric pain. There was a history of syphilitic infection twenty years before, with tabes dorsalis diagnosed twelve years before admission. Examination showed that he was poorly nourished and chronically ill. There was an area of erosion with hard rolled edges on the left margin of the tongue. There were absence of the left knee jerk, loss of position sense of the toes, and a positive Romberg sign. The red blood cell count was 3.5 million. The blood Wassermann test was negative. Gastrointestinal series (2-2-48) showed narrowing of the midportion of the stomach, and two areas of ulceration. One of these, the larger, was on the greater curvature, the other opposite it on the lesser curvature (Fig. 7). On 2-14-48, there was a sudden severe pain in the abdomen, going to the shoulders. Roentgen examination showed free air under the diaphragm. An emergency laparotomy was done to repair a perforated gastric ulcer or carcinoma. It was found that there was an opening on the anterior surface of the stomach, on the greater curvature, about 3 cm. from the pylorus. This was closed. The next day, he died suddenly. At post mortem examination, the stomach showed, along the greater curvature, starting about 2 cm. from the pylorus, an ulcer about 4 cm. in diameter, with recent repair of a perforation, the sutures being still in place and the omentum adherent. This ulcer had a necrotic base, and near its center were two small thrombosed blood vessels. Separated by 0.5 cm. of normal mucosa from this ulcer was another oval ulcer 1 cm. in greatest diameter. Cut section through this ulcer area showed a firm grayish-white tissue at its base, flecked with small yellowish nodules. Microsection revealed a denuded area showing, beneath a small amount of debris, a thin layer of fibrous tissue, and below this smooth muscle moderate round cell infiltration (Fig. 8). One section showed the denuded surface consisting of necrotic muscle and small round cells. There was no evidence of malignancy. Another microsection disclosed normal lymph node architecture, with no evidence of tumor.

Comment. This patient had two gastric ulcers, both of them benign. The greater curvature ulcer perforated. The roentgen examination showed narrowing of the lumen adjacent to the ulcers.

Case V. H. W., R# 333 221. This sixty-two year old white machine shop worker was

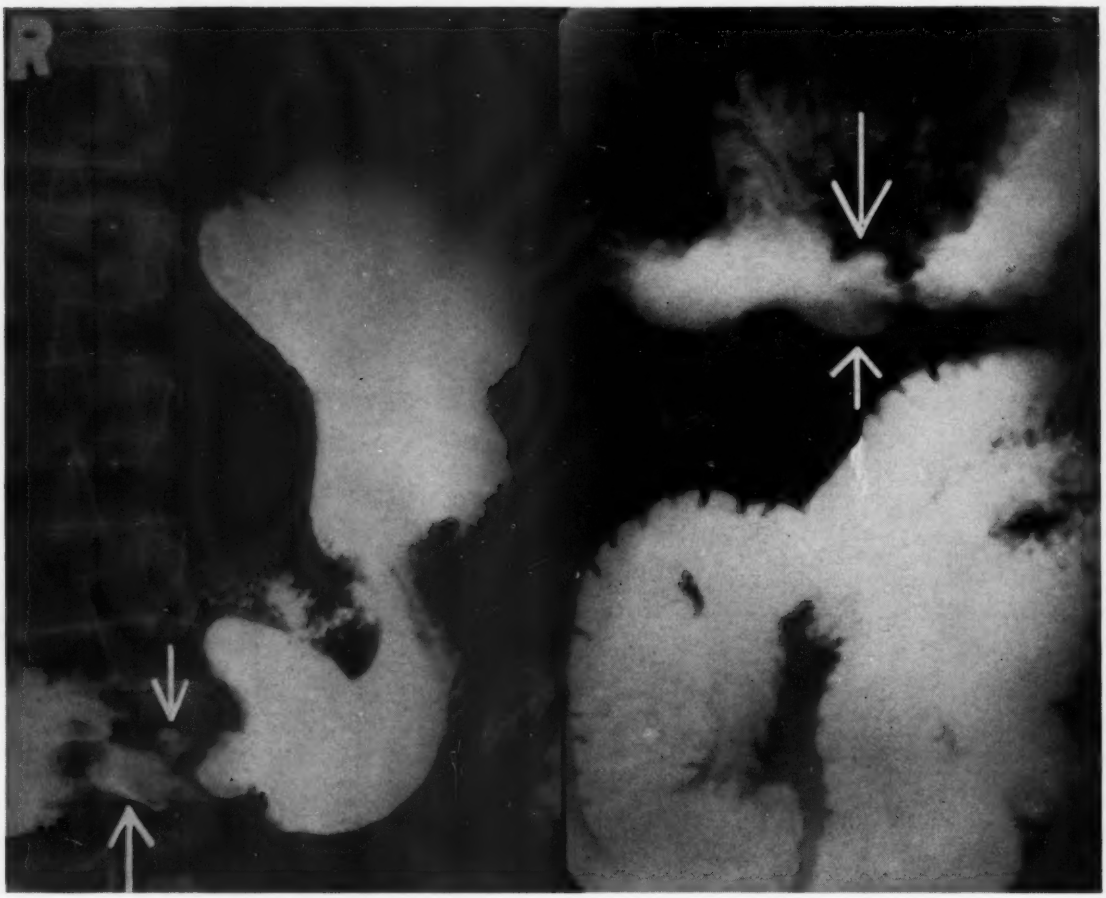

FIG. 7. (2,585h, i.) Case IV. W.D. Two benign ulcers, the larger on the greater curvature, the other opposite it on the lesser. The former perforated two weeks after this roentgenologic examination.

admitted with a history of upper abdominal pain, nausea, vomiting and hematemesis of four days' duration. On previous admission to this Hospital in 1948, a diagnosis of duodenal ulcer was made. Since that time, he was not on ulcer management and had no gastrointestinal symptoms until those referred to above. Physical examination showed slight cardiac enlargement, blood pressure 145/95, bilateral otitis media, left inguinal hernia, and moderate central epigastric tenderness. Laboratory data: Red blood cell counts varied between 3.6 and 4.1 million, hemoglobin being 12 grams. Gastric analysis showed no free fasting acid, and after histamine, 10 units free acid. Gastrointestinal series (10-31-52) disclosed in the prepyloric region an ulceration on the greater curvature, extending somewhat posteriorly, with radiating folds around the ulcer, and appearing grossly benign in spite of its location on the greater curvature (Fig. 9). A week later, gastrointestinal series showed the ulcer slightly smaller, with radiating folds. Gastroscopy was not successful in visualizing the antrum. A subtotal gastric resection (Billroth I) was done 12-4-52. The surgeon found that there was marked scarring of the anterior and posterior aspects of the stomach in the prepyloric greater curvature region. Posteriorly, the scarred ulcer was adherent to the pancreas. There was no evidence of metastases.

The pathological report was as follows: "The specimen consists of a piece of tissue sent for frozen section, 1 cm. in greatest diameter. Microsection shows a segment from the wall of the stomach. The epithelium over the surface is intact except for small denuded areas due to handling. The surface epithelium is well differentiated. The tips of the glands project into irregularly arranged connective tissue

and smooth muscle. The stroma is increased about the glandular elements and shows a chronic inflammatory reaction. Fibrous stroma is definitely increased. The muscularis mucosae is not a well defined line but is distorted and partially obliterated by fibrosis. The submucosa as a definite layer is absent. Many of the lymphatic channels and small veins show numerous polymorphonuclear leukocytes within their lumen. Diagnosis: Healing gastric ulcer."

Postoperatively, he developed an abscess in the operative wound which was drained. This later healed. There was also an episode of pleurisy which cleared quickly. He was discharged 11-22-52. Follow-up examination 2-25-53 showed no abnormality. Gastrointestinal series was negative for recurrent disease.

Case vi. L. F. F., R# 344 302. This forty-one year old white male truck driver first had rheumatoid arthritis early in 1940, was hospitalized for six months elsewhere. Later he was given cortisone with relief of symptoms. In December of 1951, he began to have burning epigastric pain, relieved by food. He received ulcer treatment and stopped taking cortisone. In the past five months he had episodes of epigastric pain going to the back which would waken him at night.

On physical examination, he was well developed and well nourished, and showed tenderness to the right of the umbilicus, no abdominal rigidity or mass. Laboratory: Blood showed: Red blood cells 5.1 million, hematocrit 50, bleeding time 50 seconds. Stools showed occult blood on a few occasions. Gastroscopy was negative on 4-8-53. Gastrointestinal series 3-20-53 revealed a small ulcer in the prepyloric region, and thickened folds in the antrum. The ulcer appeared benign. Gastrointestinal series on 4-3-53 showed a niche in the prepyloric region on the greater curvature side, with radiating folds in the region of the ulcer. The smaller crater noted on the earlier examination was no longer present. There was no five hour retention. At operation, 5-1-53, a scarred ulcer of the greater curvature just proximal to the pylorus was demonstrated. This was firmly bound down to the underlying pancreas, and appeared grossly benign. No lymph nodes were seen. A subtotal gastric resection was done. The surgeon stated that the greater curvature ulcer just on the gastric side of the pylorus was cut through in doing the operation.

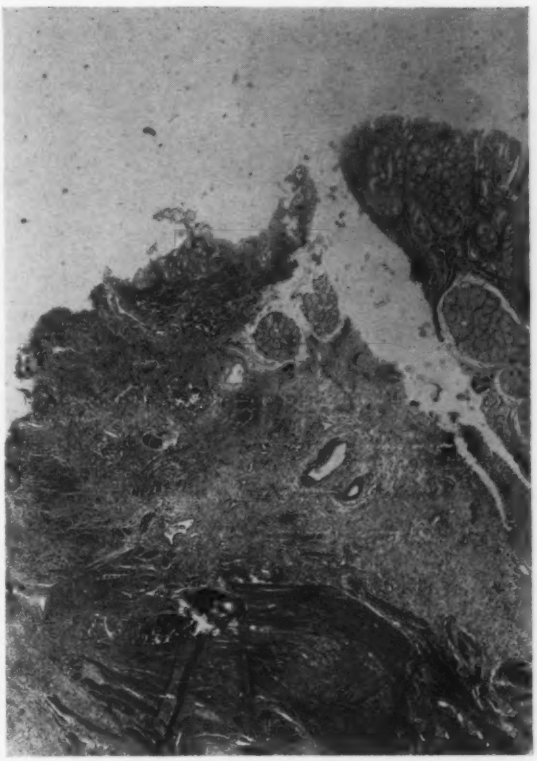

Fig. 8. (2,585j) Case iv. The base of the ulcer consists of granulation tissue and atrophic irregularly arranged smooth muscle fibers and bundles. A few small groups of gastric and Brunner's glands are present in the base of the ulcer. The adjacent mucosa consists of gastric and Brunner's glands. The muscularis is somewhat irregularly arranged and is interspersed with bands of fibrous tissue.

Pathological report: "There is a partly healed ulcer measuring 2×3 cm. The mucosa is depressed in this area. There is an associated hypertrophic gastritis. Histology: There is a deep depression in the mucosa, but glandular elements cover the whole surface. In the base, there is some irregularity of the glandular elements, some of which are rather dilated. There is a break in the muscularis mucosae indicating previous ulceration. There is chronic inflammatory reaction to the tunica propria. Diagnosis: Possible healed ulcer."

After surgery, the patient's course was uneventful. He stated this was the first time he was free from epigastric pain. He was discharged free of symptoms 5-15-53.

Comment. In this case, there were two benign ulcers in the gastric antrum, the larger being on the greater curvature (Fig.

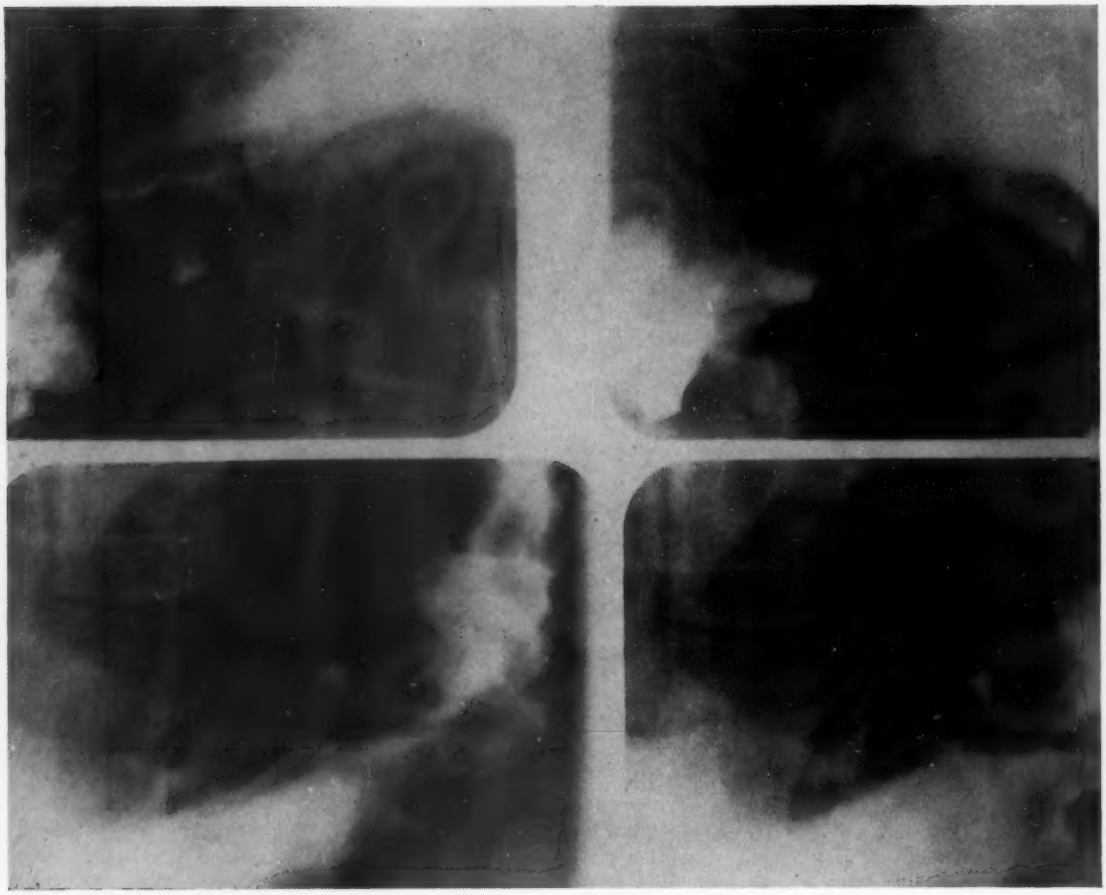

FIG. 9. (10,739b) Case v. H. W. Benign ulcer. Radiating folds can be seen around the crater. In one pressure spot-film, the crater appears to be posterior. The lesion actually was on both the greater curvature and the posterior surface. On gastroscopy, the antrum was not visualized.

10). The posterior antral ulcer was healed on the second gastrointestinal series, (Fig. 11), so that only the one on the greater curvature was demonstrated then. Gastroscopy was negative in this case. The roentgen appearance was that of benign ulceration. The ulcer symptoms dated back to the time when he received cortisone therapy for rheumatoid arthritis.

CASE VII. A. S., R# 235 621. This fifty-seven year old white man was admitted 1-27-49, complaining of sharp and cramping pains in the lower abdomen 2 to 4 times daily, weight loss of 10 pounds in the past year, and constipation. On examination, the liver was enlarged on the right. No masses were felt in the abdomen, which was scaphoid. The left epididymis was enlarged and tender. Laboratory findings were negative, except that gastric analysis showed no free acid, and the total acid was 24 units. Roentgenograms of the gastrointestinal tract on 2-2-49 showed a large crater on the greater curvature of the stomach. On the spot films there was described "widening of the gastric folds" in this area. It was stated "There is no definite evidence of malignancy on the films." but the preoperative impression of the radiologist at the tumor board was that the changes in the mucosa surrounding the ulcer were roentgenologically compatible with carcinoma. Gastroscopy on 2-9-49 revealed a gastric greater curvature ulcer, probably malignant. At operation, 3-18-49, a large tumor was palpable on the greater curvature and fundus of the stomach, also in its posterior aspect. There were multiple metastases throughout the abdomen, including the liver and peritoneum.

The tumor was considered inoperable. A biopsy was taken of a metastatic node in the greater omentum. The histologic report was that this contained "Fibrous tissue in which there was an infiltrating tumor made up of epithelial cells forming atypical glands." The pathological diagnosis was metastatic adenocarcinoma. No further therapy was indicated, and patient was discharged 3-28-49. He was readmitted 5-19-49, complaining of epigastric pain and loss of weight. He was emaciated. His liver was markedly enlarged and irregular. The abdomen was moderately distended. He became progressively worse and died 6-9-49.

Comment. This was a case of a malignant greater curvature ulcer which was erroneously reported to be roentgenologically benign. Another member of the Department of Radiology stated at the tumor board preoperatively that this had the appearance of an ulcer associated with carcinoma. The filling defect and the abnormal folds adjacent to the crater would seem to justify a roentgen diagnosis of grossly malignant ulcer (Fig. 12).

Case VIII. H. S., R# 330 802. This sixty year old white postal clerk was admitted to the hospital 9-12-52. There was a history of moderate weakness for two months, loss of 15 to 18 lbs. weight, and constipation for two months. There were tarry stools two weeks before and four days before admission. There was slight vague upper abdominal discomfort, not related to eating. Examination showed no evidence of abdominal mass. There was a right upper quadrant scar due to cholecystectomy, and a right lower quadrant scar resulting from appendectomy. There was tenderness above the umbilicus and to its right. The laboratory examinations showed that the red blood cell count varied from 3 million to 3.4 million, the hemoglobin being 10 grams. The stools showed the presence of occult blood. The gastric analysis showed no free acid on the fasting specimen, 50 units total and 34 units free acid with histamine. Three gastrointestinal series were reported negative. Gastroscopy on 10-8-52 revealed a polypoid annular lesion opposite the incisura and on the greater curvature, with a crater, suggesting malignancy. Gastrointestinal series then showed a large ulcer in the fundus, on the greater curvature side (Fig. 13).

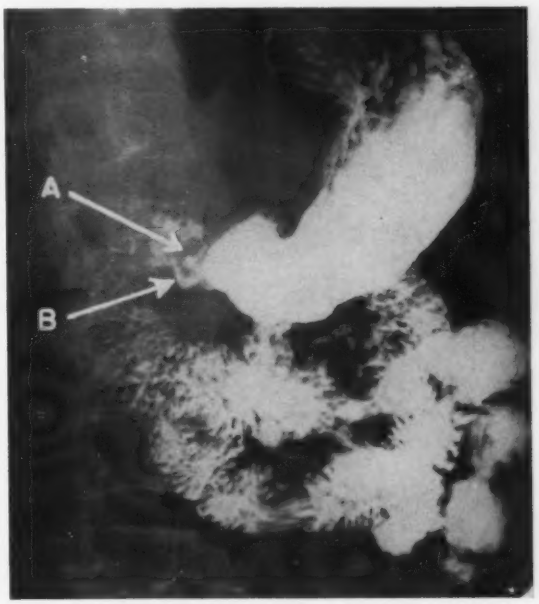

Fig. 10. (11,778a) Case VI. L.F.F. Upper arrow points to posterior antral ulcer, lower arrow to greater curvature ulcer.

Around the crater, on the spot films, there was seen a smooth halo-like defect (Fig. 14). Because of this and the absence of radiating folds, the roentgen impression was ulcerating carcinoma of the greater curvature, but the gastroscopic findings were already known to the radiologist. On abdominal exploration on 10-23-52, a carcinoma of the midportion of the greater curvature was seen, and a sleeve resection of the stomach done. Peritoneal seedings were found on the posterior wall of the stomach along the gastrosplenic ligament, and about the celiac axis. The pathologist's report: "The specimen consists of stomach and omentum. There is an ulcerating lesion 3.5×2 cm. Its edges are heaped up and nodular, firm in consistency. Microsection shows stomach wall and infiltrating tumor made up of epithelial cells which are hyperchromatic and forming atypical cells. Diagnosis: Adenocarcinoma." The postoperative course was uneventful. The patient was discharged 11-5-52.

Comment. This case of malignant greater curvature ulcer was missed roentgenologically, and only because of the clinician's insistence on repeating the examination, and his making the correct diagnosis gastroscopically was the lesion then found roentgenologically. It was present in a loca-

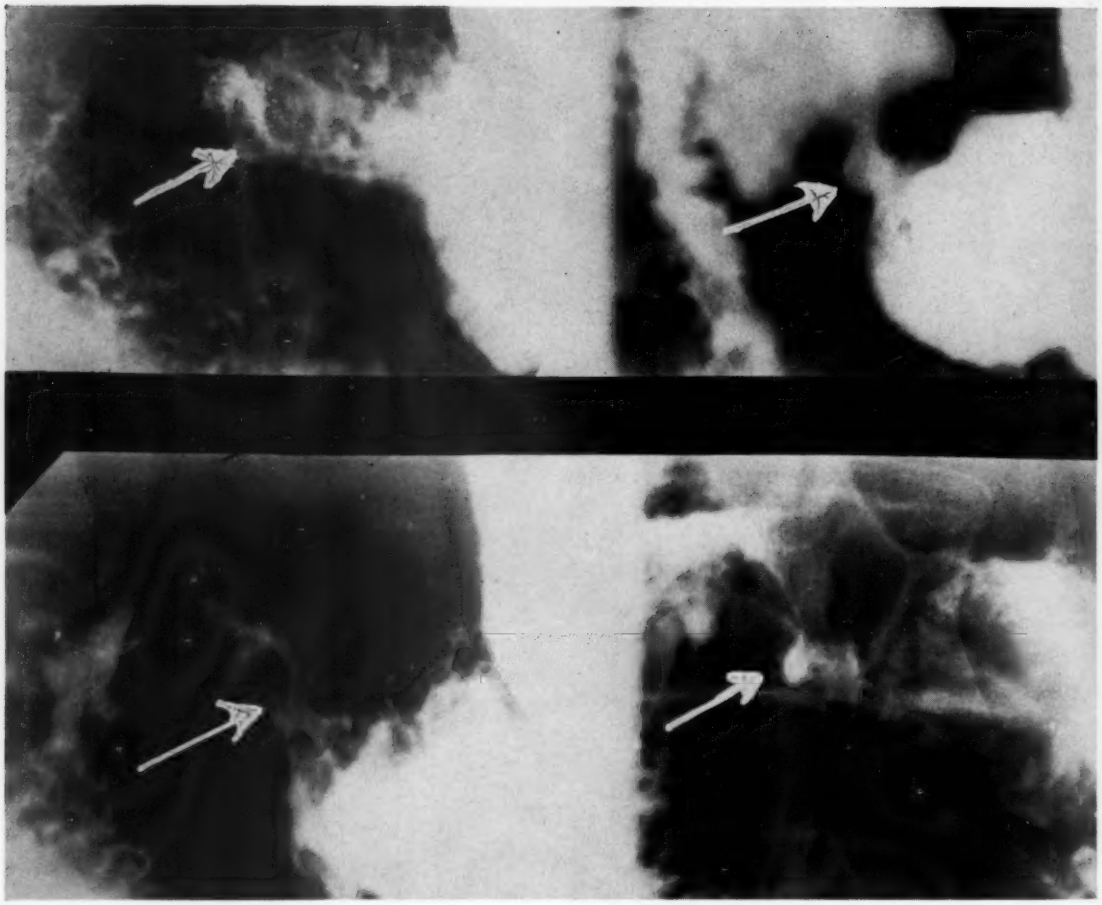

FIG. 11. (11,778b) Case VI. Two weeks later, the greater curvature ulcer is smaller, and there are radiating folds in its vicinity. The other ulcer is healed.

tion which is difficult to visualize roentgenologically, but the error was partly due to accepting technically inadequate films.

DISCUSSION

Review of the present case reports reveals that, of our 8 cases of ulcer of the greater curvature, only 2 were actually malignant. Both of these showed roentgen signs of malignancy. One was reported malignant on roentgenologic examination, but the correct diagnosis was made in this case after the gastroscopic report was made known to the roentgenologist. (The gastroscopist had an important general advantage, in that the roentgenologic examination was always made first, and the results made available to the gastroscopist before the instrument was inserted.)

In the 6 proved benign cases, a roentgen diagnosis of malignancy was made three times, and a benign lesion suggested twice. In 1 case, the roentgen diagnosis was "gastric ulcer" and should be counted as "benign." On reviewing the films, 4 out of the 6 cases would have been considered benign, probably, were it not for their location. In Case II, abnormal folds near the base of the ulcer would cause a suspicion of malignancy even on review. In Case III, there was a filling defect, and lack of healing in five weeks, factors which would justify an impression of malignancy on roentgenological grounds. In this same group of benign ulcers, the gastroscopist made the correct diagnosis once in the 4

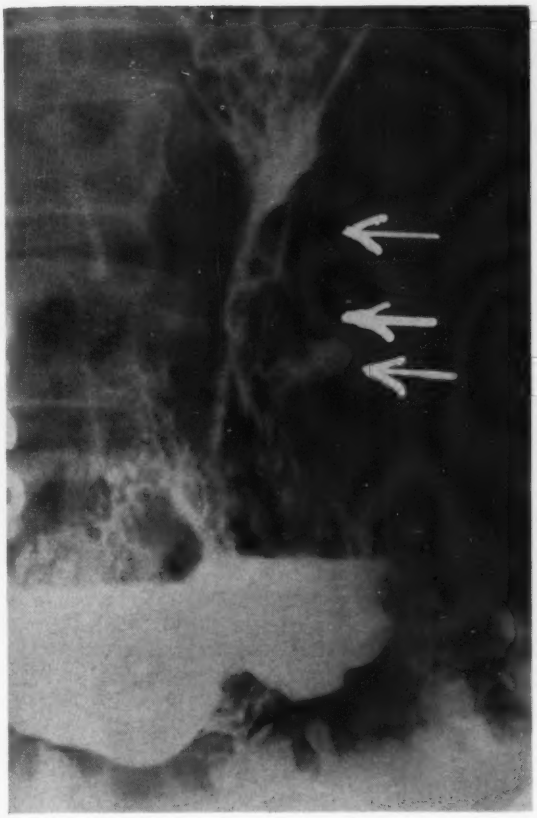

Fig. 12. (9,180c) Case VII. A.S. Malignant ulcer. The arrows indicate (from above downward) scalloped defects on the greater curvature border above the crater, destruction of the mucosa at base of ulcer indicating malignancy, and the crater itself. This was considered gastroscopically to be probably a malignant ulcer. (Reproduced by permission of *Radiology*.)

Fig. 13. (10,902b) Case VIII. H.S. Malignant ulcer. This crater was recognized only after it was found by the gastroscopist, who thought it a malignant ulcer. The altered mucosa around the ulcer can be made out on this film, but is better seen in Figure 14. The lesion appears to be in the fundus, but was located gastroscopically opposite the incisura. It was found at operation to be in the midportion of the greater curvature.

cases in which this examination was done, but failed to see any lesion in the other 3. The gastroscopist made the correct diagnosis in both malignant cases. It would appear, then, that if the location of the ulcer were ignored as a factor in the diagnosis, the correct diagnosis might have been made in 6 of our 8 cases by the usual roentgen

Table I

ROENTGENOLOGIC AND GASTROSCOPIC REPORTS OF BENIGN AND MALIGNANT GREATER CURVATURE ULCERS

	On Roentgenologic Examination	On Gastroscopy
Proved Benign Cases	1. Presumed malignant (location)	Benign
	2. Malignancy favored	No lesion seen
	3. Filling defect suggests malignancy	No gastroscopy
	4. No statement about malignancy, presumed benign	No gastroscopy
	5. Benign	No lesion seen
	6. Benign	No lesion seen
Proved Malignant Cases	7. Benign (appears malignant on review)	Probably malignant
	8. Malignant	Malignant

FIG. 14. (10,902a) Case VIII. A smooth wide halo around the crater on this relief spot film is suggestive of tumor.

criteria, a much better percentage of accuracy than one could obtain by calling all the greater curvature ulcers malignant.

The roentgenologic reports in this series of cases, it may be noted, are those of several members of the Radiologic Department, including residents in radiology.

If one considers published series of benign and malignant ulcers of the greater curvature, one is impressed first, by the wide range in the figures given for the percentage of malignancy, and then by the small numbers of cases in each series, especially the operated cases.

Reflection on the present series of cases leads me to the belief that one need not be a defeatist as to the possibility of making the correct roentgen diagnosis of ulcerative lesions of the greater curvature of the stomach. Most radiologists feel that it is possible, on the basis of roentgen criteria, to distinguish benign from malignant ulcers elsewhere in the stomach. Of course, this is based on gross appearance, and it is well known that this can occasionally deceive even the surgeon and pathologist. In a certain percentage of the cases, even the most experienced radiologist may report a malignant lesion as a benign gastric ulcer. This percentage, said Welch and Allen[26] recently, has declined to about 10 per cent, in the hands of highly competent radiologists using spot-film technique, even

TABLE II

PUBLISHED SERIES OF BENIGN AND MALIGNANT ULCERS OF GREATER CURVATURE

Author	Percentage Malignant	Total No. Cases of Ulcer in This Location
Bowers and Rivers[6]	100	4
Smith and Jordan[24]	60	5
McGlone and Robertson[17]	56	16
Silk, Blomquist & Schindler[23]	55	18
Boudreau[5]	49	47*
Horn and Ravdin[12]	39	13
Present author	25	8
Ransom[17]	20	5

* All cases found at autopsy.

in prepyloric lesions. This should be compared with their statement published in 1941[2] and again in 1945,[1] that 65 per cent of ulcerative lesions in the prepyloric region were carcinomatous. The change, they believe, is due to improved technique. If this is so, and it seems reasonable, this should increase the possibility of correctly diagnosing by roentgenologic examination even lesions situated on the greater curvature.

It was well said by Ritvo and Shauffer,[21] that "the radiologist must place reliance on the diagnostic criteria which his own experience has proven to be reliable." It might be added that the diagnosis of gastric lesions should be based on consideration of many factors, among the more important ones being all the roentgenologic data, not merely the location in the stomach.

When one tries to account for the widespread impression that ulcers of the greater curvature are almost always malignant, this hypothesis presents itself. Peptic ulcer of the stomach, for some unknown reason, occurs most commonly on the lesser curvature, and least commonly on the greater. Ulcers of this location occur in a small percentage of the total number of gastric ulcer cases in groups published by different authors, for example, 1 per cent[9] to 4.5 per cent (Hauser, quoted by Hurst and Stewart[13]). On the other hand, carcinomas of the greater curvature are not so infrequent, and some are accompanied by ulceration. As a result, most radiologists see very few benign, and relatively many malignant lesions in this location.

CONCLUSIONS

Statements usually made in the literature about the incidence of benign ulcer of the greater curvature are mostly based on previous statements in the literature, rather than personal experience The situation will not be clarified by publication of more individual case reports, which will only prove, redundantly by now, that benign or malignant ulcerative lesions in this location exist. More information is needed, and this can be provided by more published reports such as this, and Silk, Blomquist and Schindler's,[23] dealing with one's total experience of benign and malignant lesions in this location. What is important is to know, not merely how many proved benign cases of greater curvature ulcers have been seen by an individual or group, but how many malignant ones with roentgenologically benign appearance in the same period. With more information of this kind, I believe it may be possible for a radiologist to report in ulcerative lesions of the stomach without consideration of the location, "this ulcerative lesion is grossly benign," or "grossly malignant." It will then be a matter for the clinician to choose appropriate treatment on the basis of all the facts.

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ANNULAR PANCREAS IN THE ADULT

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ANNULAR pancreas is reputedly a rare congenital anomaly capable of producing varying degrees of mechanical obstruction of the duodenum. First described by Tiedemann in 1818, 104 cases have thus far been reported. McNaught[31,32] summarized the literature in 1933 and found a total of 43 cases recorded over the 115 year period. In the ensuing twenty years an additional 61 cases have been published, 41 of these since 1950. Analysis of this material provides a striking example of the evolution of a one-time laboratory curiosity into a clinical entity. Prior to 1933, 35 cases were the product of incidental observations in the anatomic and pathologic laboratories. The material since that date consists of 49 surgically treated patients, 7 laboratory reports and 1 in which the source of proof is not specified.

Curiously enough, while the impetus for clinical recognition of this variant has derived largely from roentgenologic examination of the gastrointestinal tract, relatively little attention has been accorded the subject in the roentgen diagnostic literature. Poppel[37] in 1944 briefly mentioned an annular pancreas found in association with a carcinoma of the pancreatic head and subsequently in 1950[38] discussed the anomaly in some detail, contributing 2 additional cases. Baylin[4] in 1945, Haden[20] in 1950, Harper[21] in 1953 and McGee *et al.*[30] in 1953, each added a case report. These comprise the literature to date although 41 patients have undergone upper gastrointestinal series prior to surgery or necropsy.

As noted by Silvis,[42] three phases of the anomaly are encountered clinically. In the first phase, duodenal obstruction may be so complete in the newborn that immediate surgical intervention is required. Conversely, the obstruction may be of such minimal degree that the anomaly is usually an incidental necropsy finding at any age. In the third category fall those instances productive of symptoms relatively late in the life of the individual. Although all are amenable to roentgen diagnosis, the latter two are seldom recognized and it is these with which we are concerned. In the symptomatic group it is not customary to attribute high intestinal obstruction in the adult to congenital causes. Moreover, superimposed disease involving the pancreas or contiguous organs is frequently present and may be initially responsible for the patients' complaints. The asymptomatic types are all too easily overlooked or ascribed to causes signifying less potential risk to the patient.

Three of the 6 cases summarized below were of the symptomatic variety. The remaining 3 were asymptomatic, the diagnosis of nonobstructing annular pancreas being contingent to the purpose of the examination. Verification of the roentgen diagnosis has been obtained in 5 instances. The sixth is presented as roentgenologically characteristic.

CASE REPORTS

A. *Symptomatic.*

Case 1. Male, aged sixty-six. Postprandial nausea and bloating for one year with occasional vomiting after heavy meals.

The upper gastrointestinal series showed moderate dilatation of the pylorus and duodenal bulb above a partial extrinsic occlusion of the mid-descending limb (Fig. 1*A*). The involved segment was retracted medially with some effacement but no derangement of the mucosal pattern (Fig. 1*B*).

Roentgenoscopically gastric peristalsis was ineffective and the barium bolus passed the point with difficulty.

At surgery an obstructing pancreatic ring 1 cm. thick and 4 cm. long completely encircled the descending duodenum (Fig. 1*C*). There was gross evidence of chronic pancreatitis. A duodenojejunostomy was accomplished and recovery was uneventful.

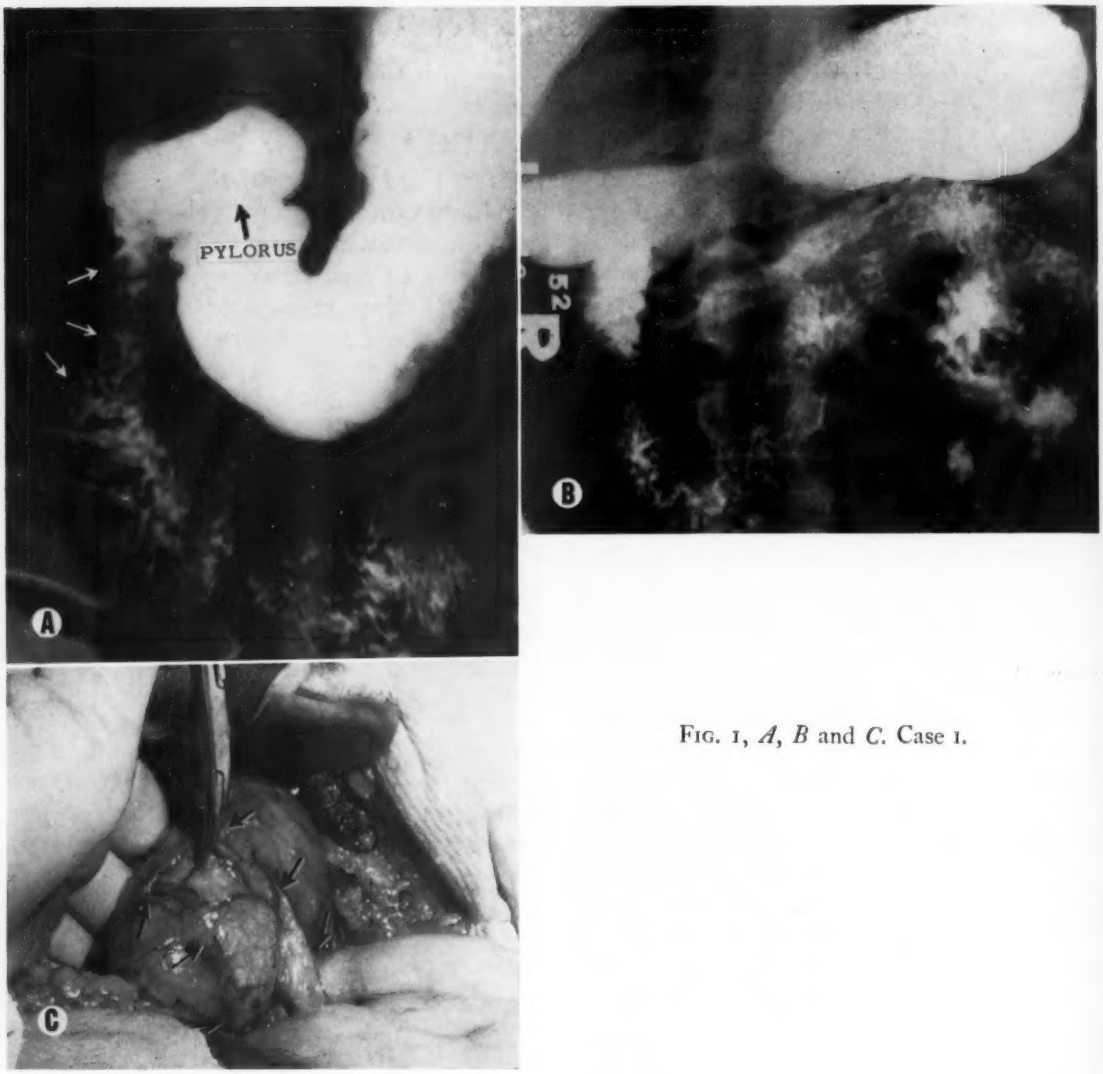

FIG. 1, *A*, *B* and *C*. Case 1.

CASE II. Male, aged fifty. Fever of four weeks' duration and epigastric pain aggravated by food. A known diabetic for eight years, the patient had been hospitalized five times previously for retropharyngeal, submandibular and subdeltoid abscesses. Repeated biopsies showed only cellulitis and granulation tissue.

Physical examination revealed a tender mass of grapefruit size deep in the epigastrium and laboratory studies a mild diabetes, leukocytosis and marked secondary anemia.

A chest film was normal; the gallbladder failed to opacify.

An upper gastrointestinal series showed extrinsic pressure upon a markedly dilated duodenal bulb (Fig. 2*A*), and medial retraction and constriction of the mid-descending duodenum (Fig 2, *A* and *B*). The mechanism by which the obstruction was initiated was felt to be either inflammatory disease within the pancreas and adjacent organs or displacement of the duodenum above the annulus by an extrinsic inflammatory mass. While being prepared for surgery the patient suddenly died.

Autopsy revealed (1) Hodgkin's sarcoma involving the retroperitoneal lymph nodes with pressure displacement of the extraperitoneal portion of the duodenum, (2) chronic interstitial pancreatitis, (3) a complete annular pancreas obstructing the descending duodenum just above the ampulla of Vater (Fig. 2*C*).

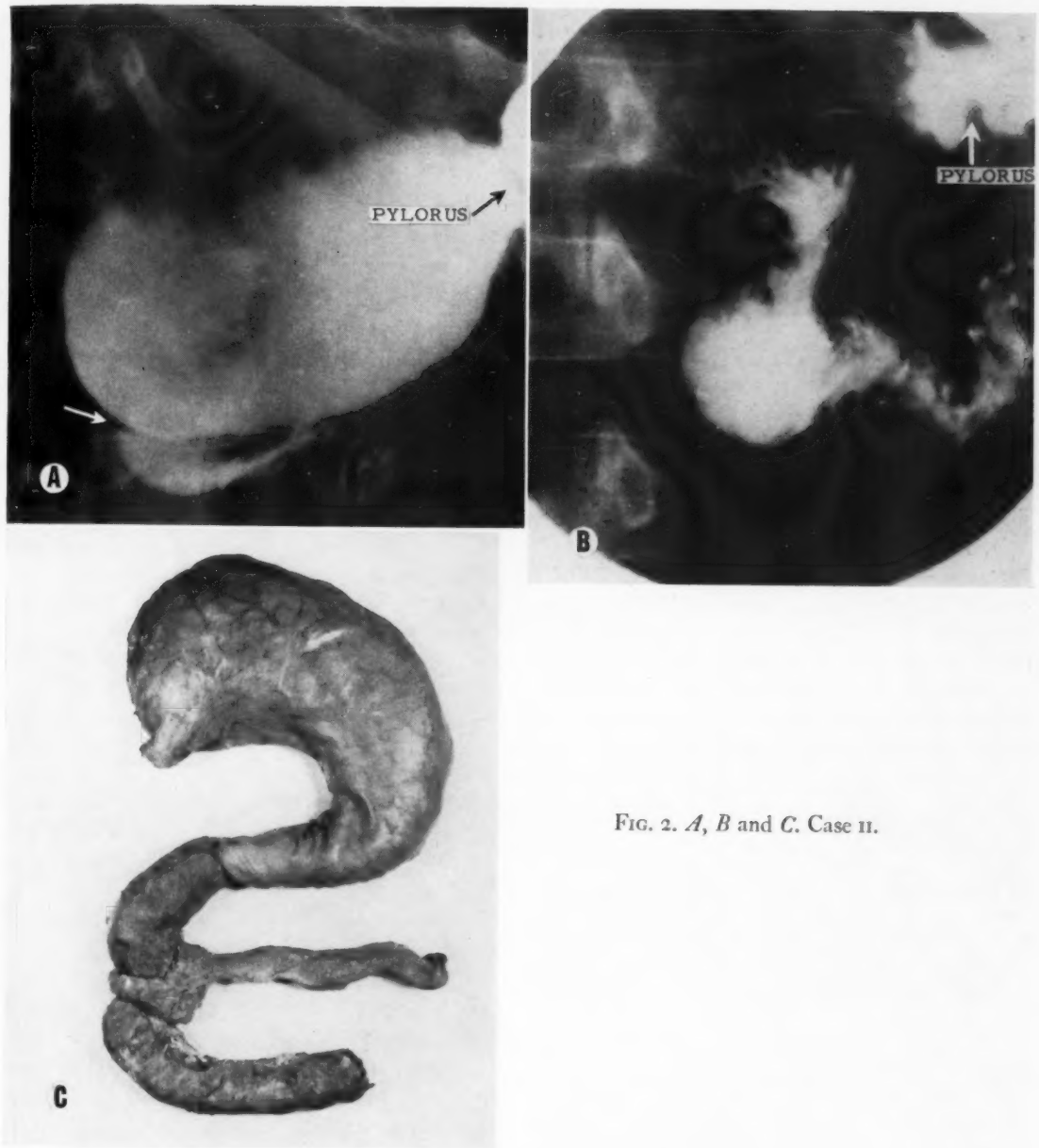

FIG. 2. *A*, *B* and *C*. Case II.

CASE III. Female, aged fifty. Recurrent abdominal pain, epigastric fullness and nausea for two years. Her complaints were not related to food intake although food was vomited twenty-four to thirty-six hours after ingestion upon several occasions. The physical examination showed only epigastric tenderness.

An upper gastrointestinal series revealed a narrow and deformed descending duodenum with bilateral extrinsic pressure defects (Fig. 3). The defect on the medial side was in the form of an inverted figure "3." The lateral defect was felt to be due to partial encirclement of the duodenum by the pancreas.

Abdominal laparotomy revealed a completely retroperitoneal descending duodenum with a partial annular pancreas embracing the second portion. The pancreas was grossly enlarged and of a doughy consistency. Biopsy of the gland showed chronic pancreatitis.

FIG. 3. Case III.

B. *Asymptomatic.*

CASE IV. Male, aged sixty-seven. Recent grossly bloody stools with a long-standing history of arteriosclerotic heart disease and recurrent congestive failure. There were no gastrointestinal symptoms except weight loss.

The upper gastrointestinal series showed a smooth, extrinsic pressure defect on the lateral side of the descending duodenum producing an eccentric narrowing of the lumen without obstruction. Both lateral margins overlapped the base of the indentation (Fig. 4*A*).

An autopsy revealed the cause of death to be myocardial infarction. An annular pancreas was found embracing the second portion of the duodenum. The posterior half of the annulus was composed of fibrous tissue (Fig. 4*B*). Superficial gastric ulceration accounted for the tarry stools.

CASE V. Male, aged sixty. Recurrent hematuria with a history of several coronary artery occlusions. A cystoscopic examination revealed an advanced carcinoma of the bladder. Bilateral ureterostomies were done. In spite of a relatively low B.U.N. the patient had recurrent vomiting.

An upper gastrointestinal series showed eccentric narrowing of the distal portion of the descending duodenum, medial retraction of the loop, and slight effacement without destruction of the mucosal pattern (Fig. 5*A*). There was no real obstruction. Pyelonephritis secondary to carcinoma of the bladder caused the death of the patient.

Autopsy revealed a partial annular pancreas

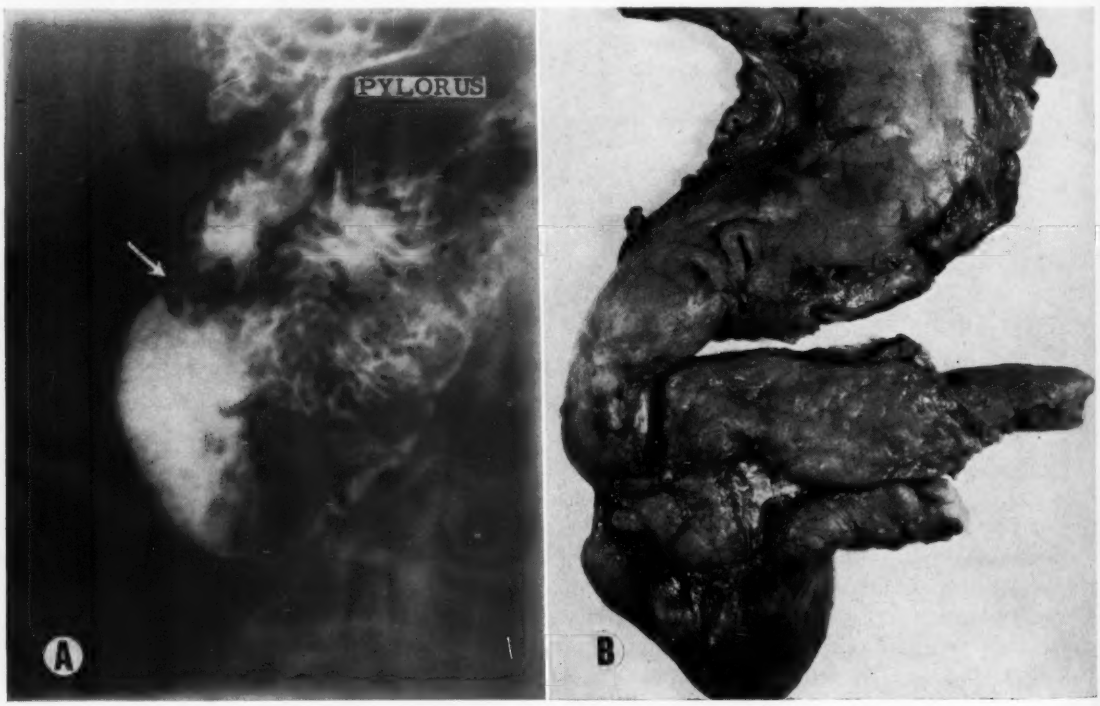

FIG. 4, *A* and *B*. Case IV.

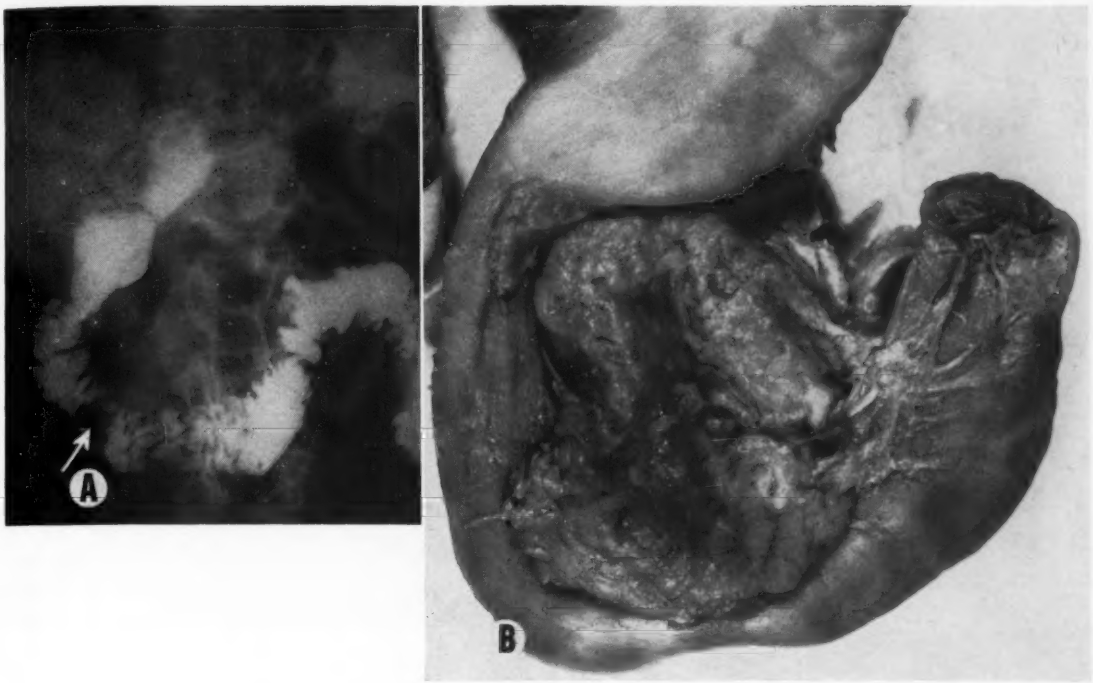

Fig. 5, *A* and *B*. Case v.

producing pressure upon the second portion of the duodenum (Fig. 5*B*). There was no fibrous extension as in Case iv. (Unfortunately, the prepared specimen does not show the notching of the duodenum at the site of the annulus as demonstrated by roentgenoscopy and autopsy.)

Case vi. Male, aged fifty-two. No complaints. Referred by American Cancer Society for 70 mm. photofluorographic examination of the stomach as a routine cancer detection procedure. Two years earlier the patient had been treated for a peptic ulcer with complete remission of symptoms.

The survey films showed a constant deformity of the duodenal bulb and slight stasis above an eccentric narrowing of the descending limb (Fig. 6*A*).

These findings were confirmed by a conventional study and a compressed but otherwise intact regional mucosa demonstrated (Fig. 6, *B* and *C*). Although surgical intervention was not warranted this case is included as roentgenologically characteristic of a nonobstructing annular pancreas.

EMBRYOLOGY AND ANATOMY

The specific mode of development of annular pancreas is still in dispute. Lerat[25] and Weissberg[49] believed it to be a simple regenerative hyperplasia of the gland following fetal peritonitis. In recent years this theory has largely been discarded in favor of Lecco's hypothesis[23] wherein failure of the tip of the ventral pancreatic anlage to rotate completely to the right and posteriorly with the duodenum allegedly produces a band of elongated pancreatic tissue about the viscus. Others contend that it is unreasonable to assume "fixation" of the left ventral bud prior to migration and believe the ventral pancreatic primordium merely spreads about both sides of the duodenum prior to fusion. Regardless of the mechanism, the result is a band of glandular tissue which embraces the duodenum circumferentially. Histologically, the ring is composed of normal pancreatic tissue including a well defined duct system which originates ventrally and sweeps about the duodenum to enter the pancreatic head and terminate in the duct of Wirsung. Occasionally the annulus is incomplete. Lehman[24] states that in such cases a fibrous defect usually occurs anteriorly at the point of fusion of the

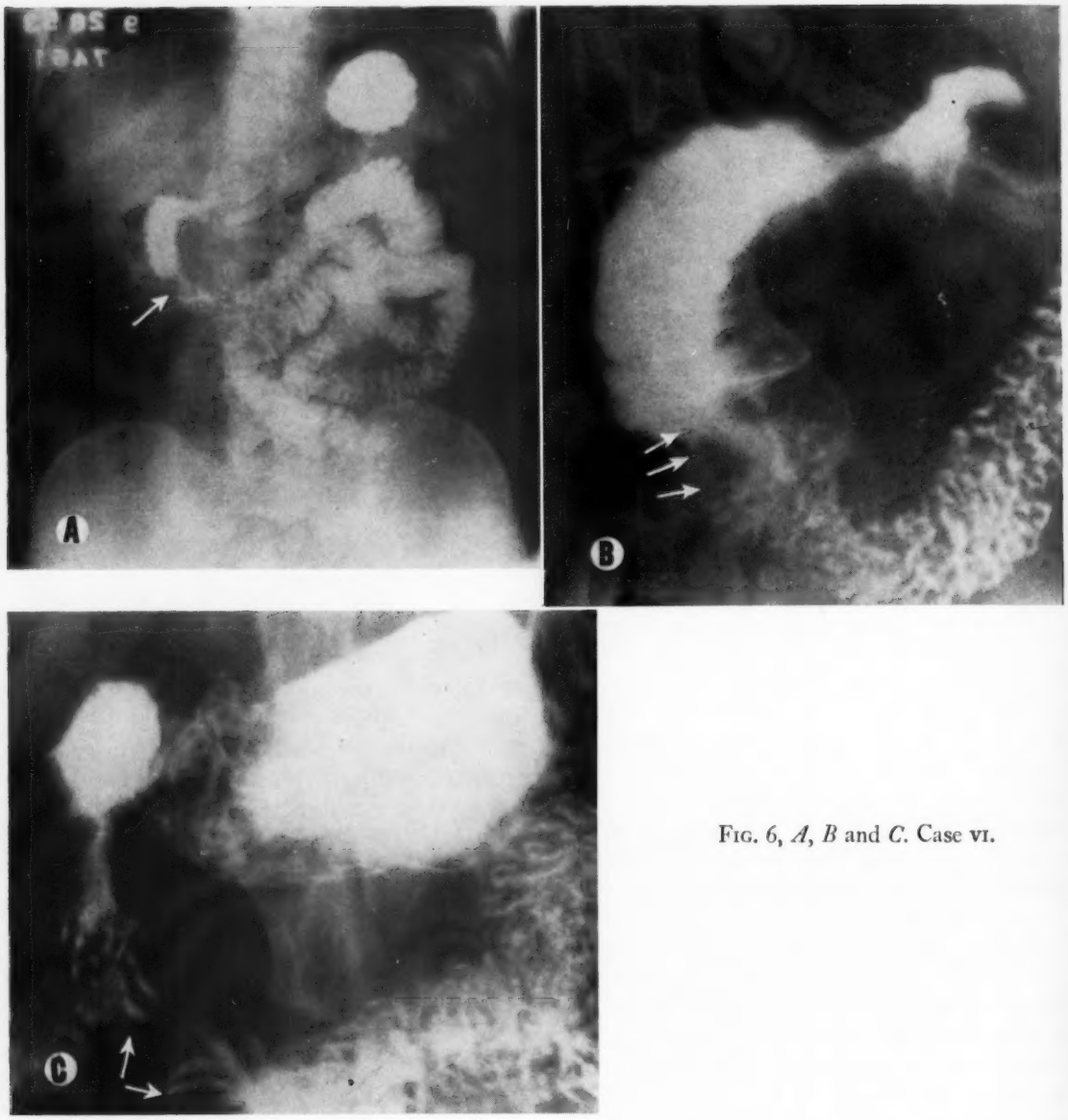

FIG. 6, *A*, *B* and *C*. Case VI.

accessory tissue with the pancreatic head. Stofer[43] has reported a case in which the gap lay posteriorly. Two of our asymptomatic annuli were incomplete. In Case IV the posterior half of the band was composed of fibrous tissue. Case V showed approximately the same amount of pancreatic tissue, but no fibrous extension.

As a rule, the descending duodenum is involved. In 87 instances where the location has been recorded, 2 encircled the first portion including the bulb and pylorus, 73 the second, 3 the third and 1 the fourth. In addition, 3 girdled the junction of the first and second portions and 1 the junction of the second and third. In 4 cases the annulus was periampullary with actual or potential biliary obstruction. Of these, 2 occurred in newborn infants with associated jaundice. The remaining 2 were adults, 1 without jaundice and 1 with jaundice and pancreatitis. Three infants were definitely icteric, but the relationship of the ampulla and annulus was not stated.

PATHOLOGY

The ratio of adult to newborn cases is approximately 4:1. Only six have been reported in the group ranging from one to twenty years of age. Thus it would seem that the usual basic pathologic process is a potential rather than an effective duodenal ileus. Evidently supervening disease serves to trigger the obstructive mechanism.

Acute or chronic pancreatitis involving the annulus or pancreas proper has a significantly high incidence in the adult years. Sixteen cases, including 3 of our own, were so afflicted. In all probability this does not reflect the true frequency. Gross or microscopic description of the pancreatic tissue is lacking in many reports, particularly in those cases which have been treated by short circuiting procedures without division of the ring. In only 9 instances has it been stated that these tissues were normal. Two cases have been associated with carcinoma of the pancreatic head.

Disease of other adjacent organs may draw attention to an asymptomatic annulus or cause obstruction by alteration of the anatomic relationship of the annulus and duodenum. Duodenal ulcer, gastric ulcer or gastric and duodenal inflammation are frequent complications. Ten patients have had duodenal ulcers of varying activity (Case v) and 5 others gastric ulcers (Case iv). Two have shown severe inflammatory reactions of the duodenum and stomach above the obstructive point. In addition, 5 have had concomitant gallbladder disease, 2 duodenal diverticula, 1 carcinoma of the cystic duct and 1 retroperitoneal Hodgkin's sarcoma (Case ii). Many have been associated with heavy periduodenal adhesions.

Nineteen patients with annular pancreas showed additional congenital anomalies. Four anomalies were directly related to the duodenopancreatic area, 2 being aberrant pancreatic tissue and 2 co-existent duodenal atresia. In all, 63 of the collected 110 cases exhibited some type of associated disease.

INCIDENCE AND SYMPTOMATOLOGY

Annular pancreas has been reported more often in males than in females. There is no race predilection. The over-all incidence cannot be accurately estimated at this time, but we concur with Baylin that the anomaly is relatively common. Certainly the influx of cases during the past three years would tend to support this belief. Five of our 6 cases were seen within a period of eighteen months.

Depending upon the degree of obstruction produced by the annulus, symptoms may never occur or may appear at any time during life. The onset may be gradual or precipitous. Symptoms range from vague, intermittent epigastric discomfort and belching or a feeling of fullness and nausea, to severe epigastric pain, recurrent vomiting and excessive weight loss. In short, the symptoms are those of any duodenal obstruction although they are frequently colored by co-existent disease in nearby organs.

ROENTGEN CRITERIA

The diagnosis of symptomatic annular pancreas in the immediate postnatal period does not require an upper gastrointestinal series. As noted by Shapiro *et al.*[41] an erect film of the abdomen will exhibit the so-called "double bubble sign" representative of air-fluid levels in the dilated stomach and duodenum. This sign is not specific, but does indicate duodenal obstruction and the need for immediate surgery. Under such circumstances precise etiologic diagnosis is not essential.

In the adult the plain film will not suffice. Indeed, contrast studies of the stomach and duodenum provide the only clinical means of establishing a diagnosis. Changes common to any mechanical occlusion of the duodenum are encountered proximal to the annulus, *i.e.*, dilatation, reverse peristalsis and pyloric incompetency with or without gastric dilatation (Fig. 1*A*, 2*A*, 2*B*). These signs, of course, vary with the degree of obstruction. Fortunately, from the standpoint of both the patient and the radiolo-

gist, obstruction is rarely complete in the older age groups. Analysis of the constriction is therefore feasible, permitting a correct diagnosis in the majority of cases.

At the level of the annulus the duodenum is retracted toward the head of the pancreas by the encircling tissue. The notch-like pressure defect thus produced upon the outer border of the loop seldom exceeds 1 to 3 cm. in length and is characterized by a smoothing or compression of the underlying mucosa and an eccentric narrowing of the lumen (Fig. 1*B*, 2*B*, 4*A*, 5*A*, 6*C*). When the annulus is narrow, the lumen tends to overhang either side (Fig. 4*A*, 6*B*). Occasionally related disease in the pancreatic head will encroach upon the medial aspect of the duodenum (Fig. 3) and infrequently a large and complete ring produces a symmetric constriction.

Distal to the annulus the diameter of the lumen may be normal or diminished depending upon the degree and duration of obstruction.

Postbulbar ulceration and duodenal neoplasms provide the only significant obstacles to correct interpretation. Cholecystoduodenocolic bands are a more frequent cause of congenital obstruction than annular pancreas, but these usually involve the bulb, a rare location for the latter. The roentgen findings in cholecystoduodenocolic bands may disappear in the right anterior oblique position in contradistinction to the pancreatic anomaly where the deformity is accentuated by this maneuver. Other congenital sources of obstruction such as diaphragms, aberrant blood vessels and atresia provide no differential problem in the adult.

As shown by Ball, Segal and Golden,[3] the characteristic roentgenographic sign of postbulbar ulceration is a smooth, rounded indentation in the wall at the level of the crater. Most commonly seen on the lateral side of the loop, it produces a narrowing of the lumen quite similar in many instances to the deformity of annular pancrease. The presence of a crater within or opposite the deformity is the most reliable differential sign. To date, coexistent duodenal ulceration at the level of the annulus has not been described. In those cases in which a niche cannot be clearly demonstrated it is necessary to rely upon the secondary manifestations of ulceration. Ball and his co-workers found diffuse irritability of the proximal duodenal segment with mucosal edema and localized derangement of the valvulae conniventes in all of their cases. In no instance was any degree of obstruction produced.

Destruction of mucosa is the outstanding feature of the malignant duodenal tumor. A lesion which encroaches upon the lumen without basically altering the mucosal pattern is more likely to be benign.

Occasionally the overhanging edges of the duodenum about a relatively thin annulus will simulate a broad-based polyp (Case IV). Observation of the peristaltic movements of the loop readily obviates this possible source of error.

It is conceivable that inflammatory adhesions may at some time produce an identical roentgenographic appearance. By and large, however, localized medial displacement of the loop with mucosal effacement and bulging of the recesses on either side of the band constitute a reasonably characteristic roentgen complex.

SUMMARY AND CONCLUSIONS

1. It is suggested that annular pancreas is a relatively common anomaly. The literature is reviewed and six new cases are presented.

2. The clinical pictures are: (a) complete duodenal obstruction in the newborn; (b) minimal obstruction producing few or no symptoms; (c) chronic or acute duodenal obstruction occurring relatively late in life. Superimposed disease frequently initiates the obstructive symptoms in the last group.

3. An upper gastrointestinal series provides the only clinical method of making the diagnosis in the adult. The characteristic roentgen findings are localized medial retraction of the second portion of

the duodenum, thinning of the underlying mucosa and eccentric narrowing of the lumen.

4. Postbulbar ulceration and duodenal neoplasms present the major differential items, but careful analysis of the obstructive point should result in correct diagnoses in a high percentage of cases.

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Vol. 75, No. 2

ENTEROLITHS IN THE SMALL INTESTINE*

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ALTHOUGH enteroliths of the appendix and colon are not infrequently encountered in medical practice, the occurrence of enteroliths in the small intestine is considered to be of sufficient interest to justify this case report and to present a review of the literature. The mechanisms for stone formation in the intestinal tract are also discussed.

REPORT OF CASE

B. R., a thirty-year old white married male, was admitted to the hospital in June, 1944, with a diagnosis of pulmonary tuberculosis detected on a draft board chest film examination of April, 1944. An appendectomy had been performed thirteen years prior to admission. During 1944 and 1945 the patient experienced repeated episodes of intermittent abdominal cramps accompanied by some diminution in size of the stool, abdominal distention and vomiting. These bouts of abdominal discomfort subsided spontaneously. It was felt that he might have developed adhesions subsequent to the previous appendectomy. A barium enema examination in January, 1945, was normal. All bacteriologic examinations had been negative for tubercle bacilli. A study of the small intestine in May, 1945, showed some segmentation of the terminal ileum but no evidence of organic disease. No calculi were present.

The patient was admitted to another hospital in November of 1947, with a diagnosis of intestinal obstruction. Exploratory laparotomy revealed the presence of inflammatory disease extensively involving the distal 6 feet of terminal ileum, cecum and ascending colon. No resectional surgery was done. Biopsy of a mesenteric lymph node showed tuberculous granulation tissue with acid fast bacilli present. The patient was discharged in January, 1948, and was started on streptomycin therapy which was followed by a decrease in the frequency of attacks of abdominal pain. However, by April of 1948, there was a recurrence of these attacks suggesting partial intestinal obstruction.

The patient was readmitted to the hospital in Novemeber, 1952, with a diagnosis of intestinal obstruction. Roentgenograms of the abdomen showed small bowel obstruction with multiple calculi noted for the first time. These calculi were aggregated in the lower abdomen and appeared to be in the area of the terminal ileum. (Fig. 1). There were 18 calculi noted presenting an oval-to-round contour, each measuring 1–2 cm. in diameter. Each calculus had a sharply defined dense margin with a relatively radiolucent center. The patient's symptoms subsided after the passage of 3 stones per rectum, which, on analysis, were thought to be gallstones containing calcium phosphate with bile pigments and cholesterol centrally. An oral cholecystogram showed a normal gallbladder and no gas was present in the extrahepatic biliary system. A barium meal examination showed a delay in transit through the small intestine with sites of narrowing in the mid-ileum (Fig. 2) and terminal ileum (Fig. 3) at its insertion into the colon, each stricture measuring 1 cm. in length. The intraluminal position of the calculi in the distal ileum was indicated by the appearance of multiple filling defects in the barium column (Fig. 4). The calculi on occasion showed considerable mobility within the abdomen and were frequently clumped together in the region of the terminal ileum (Fig. 5, 6 and 7).

Surgery done in February, 1955, disclosed dilatation of the terminal 2½ feet of ileum with stricture formation. The most proximal scar narrowed the ileum to a caliber of 4–5 mm. and

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FIG. 1. Calculi are noted in the lower abdomen, mostly to the right of the midline in the region of the terminal ileum.

was located 2½ feet from the ileocecal valve. The enteroliths could be felt to be lying free within the lumen of this segment from the stricture to the ileocecal valve. Water and gas could not be easily expressed into the cecum. The calculi could not be passed into the colon because of the stricture at the ileocecal junction. An incision into the terminal ileum permitted removal of the enteroliths. Analysis of the enteroliths showed the core to be made up mostly of insoluble fibrous matter. The exterior contained earthy phosphates and a little calcium carbonate. There were no urates, oxalates or cholesterol.

DISCUSSION

The earliest case of enteroliths in the small bowel acknowledged in the twentieth century was that reported by Williams[23] in 1908, occurring in an eleven year old male with a calculus in the lower ileum. Edwards[10] in 1930, reviewed the literature and noted 15 cases of various types of enteroliths causing obstruction in addition to the case he reported of a large stone near the ileocecal valve. De Witt, Morrissey and Failla[9] noted 7 cases of primary calculi of the small bowel causing intestinal obstruction up to 1943. They added a case report of a calculus found in the lower ileum, in a patient twenty-six years of age.

According to Frink[12] not more than 25 cases of enteroliths had been reported in the literature up to 1952. It is quite likely that many cases have not been reported and that some have been misinterpreted as gallstones in the intestinal tract. Some cases may be asymptomatic and remain undetected except as incidental findings.

Enteroliths may occur in any portion of the intestinal tract. Recorded with greatest frequency are those in the stomach (bezoar), the appendix (coprolith) and the colon (fecolith, fecaloma). Enteroliths can be considered primary or secondary in

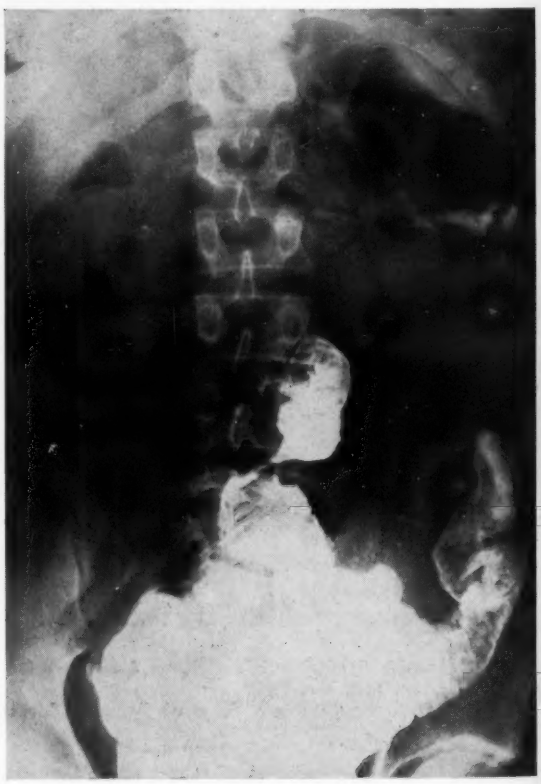

FIG. 2. A barium meal examination shows a zone of inflammatory narrowing in the mid-ileum.

Fig. 3. There is narrowing of the terminal ileum in the same motor meal.

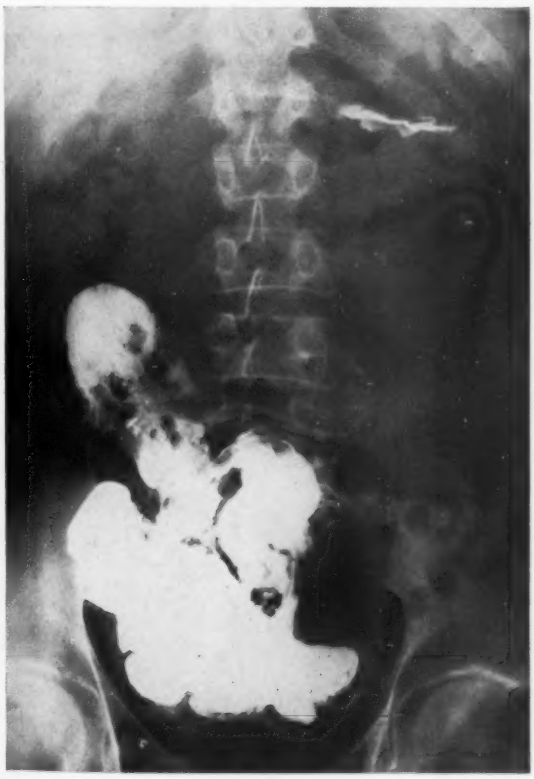

Fig. 4. Intraluminal radiolucent defects in the distal ileum indicate the presence of concretions previously described.

Fig. 5. Demonstrates mobility of the calculi in the small bowel.

type.[14] Gallstones are representative of secondary enteroliths and may enter the intestine by way of the common duct or by development of a fistula between the biliary tract and the gastrointestinal tract (usually stomach, duodenum or colon).

Primary enteroliths can be subdivided into: 1, true enteroliths and 2, false enteroliths.[8,11,14,22] True enteroliths are the less common and are formed by the precipitation of substances normally found in the intestinal tract. Included are 4 stone types with the following distinguishing chemical and clinical features:

(a) Ammonium-magnesium phosphate, calcium phosphate and calcium carbonate. Inasmuch as these salts are soluble in water and acid reaction, they require an alkaline environment for precipitation and are thus usually found in the colon or terminal ileum.[4,19]

(b) Calcium oxalate. Such stones are very rare.

FIG. 6. Same as Fig. 5. Demonstrates further mobility of the calculi.

(c) Choleic acid. These enteroliths are encountered invariably in women and require an acid environment for their deposition, being encountered in the small intestine. [2,4,12]

(d) Hydroxy fatty acids.

False enteroliths, even though rare, are encountered more frequently than the primary type and can be divided into 4 groups:

(a) An agglutination of large amounts of ingested material which is difficult to digest or is indigestible (e.g., bezoars).

(b) Precipitation of substances in the intestinal tract which become insoluble in water and digestive juices because of resorption of their solvents (e.g., varnish stones encountered in varnish drinkers).

(c) Concentration of water suspended insoluble salts due to loss of water during transit through the intestine (e.g., medicinal stones due to ingestion of barium sulphate, chalk, lime, salol, milk of magnesium and aluminum antacids[6,14]).

(d) Stasis and inspissation of intestinal content which may be associated with incomplete mechanical obstruction (e.g., fecaloma of colon, coprolith of the appendix, meconium ileus and peritonitis of infancy and enteroliths in diverticula, particularly Meckel's diverticulum[3,5,13]).

In the formation of enteroliths, the nidus or layers of the enteroliths may be represented by a foreign body such as fruit stone, cellular debris under normal or inflammatory states and bacteria. More often enteroliths are formed without any definite nucleus.

Some enteroliths may enter the intestine after being formed in diverticula, especially a Meckel's diverticulum.[7] The original site may be established by comparing the size and shape of the diverticulum to the stone. Multiple stones may develop in a divertic-

FIG. 7. Same as Fig. 5 and 6. Demonstrates still further mobility of the calculi.

ulum and consist of fecal material and bile pigment. These stones are sometimes faceted in appearance and thus may be difficult to differentiate from gallstones.[1,18] Dietary factors may be responsible in some instances. Enteroliths are known to commonly occur in horses where they have been attributed to the husks of oats.[22] The enteroliths frequently vary their position in the intestine and this movement is reflected in a varying stratification pattern of the stone.[4] Stricture of the intestine with resulting stasis and enterolith formation has been encountered in the literature.[21] As in our case, Kelly[16] reports a patient in which the stricture is probably tuberculous in origin. Congenital and post-traumatic strictures have been reported by others.[5,12,14,17]

Enteroliths are of obvious clinical and roentgenologic importance. Their detection depends upon the amount of calcium present. Enteroliths must be differentiated from the multiple causes of intra-abdominal calcification including gallstones, calcifications in the pancreas, calcified mesenteric lymph nodes, ovarian and uterine calcification, echinococcus cysts, calculi in the urinary tract, calcified vascular aneurysms (splenic, renal) and other less common opacities. Enteroliths are usually oval or round and may be laminated or homogeneously calcified. In most instances, the locations, size and pattern of the calcium deposition will generally establish the correct diagnosis.

Most calcifications in the abdomen are relatively easy to locate structurally and we will not discuss the distinguishing characteristics of the many intra-abdominal calcifications indicated above. However, difficulties may be encountered in differentiating enteroliths from gallstones in the small intestine.[20] Where gallstones in the bowel are present one is likely to find air in the biliary tree. This finding is not seen in small intestinal enteroliths. Additionally, other calculi will most likely be found in the gallbladder which is generally closely related to the hepatic flexure.[15]

The enteroliths themselves can result in an incomplete or complete mechanical bowel obstruction and should be searched for in an acute abdomen of obscure etiology. The location of enteroliths within the intestinal tract may be confirmed by a barium meal or barium enema examination.

The present case can be considered one of false enteroliths resulting from stasis secondary to incomplete mechanical obstruction of the lower ileum. The fibrous matter making up the core of these enteroliths may have been of dietary origin.

SUMMARY AND CONCLUSION

1. A case of enteroliths of the small intestine is reported and the literature reviewed.

2. A discussion of etiology, mode of formation, classification and differential diagnosis of small intestinal enteroliths is included.

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DUPLICATION OF THE COLON: A CASE PRESENTATION

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THIS is a case presentation of a double colon which extended from the cecum to the rectum, associated with a single bladder, urethra, vagina, and uterus. The left kidney and ureter were absent. This is the only case of this kind found in the literature. Only 5 other cases were similar. Only one other case of complete colon duplication[17] has been diagnosed roentgenologically.

Of 22 previously reported cases of double colon found in the literature, 11 had genital or vesicogenital duplications.[14,15] One of these was a parasitic monster with a small headless parasite attached by its neck to the thorax of the host. The abdominal organs of the parasite were in the abdomen of the host. Excluding the last case and adding our own, there are 13 females and 4 males reported in the literature. Seventeen of the 22 had involvement of the entire colon, and in 5 the terminal ileum was also involved. There were two colons, which were double, extending to Meckel's diverticulum. Ten of the 22 cases had a double appendix, and all had a proximal communication with the fecal stream. One, or both, of the openings, however, was usually inadequate. Thirteen of the 22 had an anomaly of the lower urinary tract. Only one additional case[17] was found to have a single ureter and kidney. It is quite probable that a thorough exploration of the abdominal cavity was not done in all cases, however. Nine of the 13 had a double bladder; 4 had anomalies of the genital tract; one[8] had no external genitalia; 3 had kidney anomalies. Two were triplications (Gray and Diaz) of the colon. Other associated anomalies were exstrophy of the bladder, double vertebrae, omphalocele, and double pelvis. Ten of the 22 died as a result of their anomalies.

REPORT OF CASE

A white female, G.H., aged eleven years, had noticed incontinence of feces, and on occasions fecal material was discovered to come from her vagina. Examination roentgenologically at another institution had indicated a fistulous communication between the rectum and the perineum. A barium enema examination was performed at St. Luke's Hospital and a double colon was diagnosed roentgenologically. The patient was re-examined and the duplication was found to extend from a common cecum to the rectum—the posterior normal colon emptying into the rectum, and the anomalous colon ending in a fistulous tract which entered the vagina posteriorly, just proximal to the vaginal hymen. During the colon examination, the normal colon filled in retrograde manner, and the single terminal ileum was seen. The anomalous colon then filled from the cecum, distally to the fistulous tract. There were no other communications found between the normal and anomalous colon. Instillation of contrast material into the vagina outlined a normal organ, and retrograde instillation into the fistulous tract filled the anomalous colon duplication.

An intravenous pyelogram revealed a normal, single, right kidney, ureter, and bladder, with absence of the left kidney. The patient was in excellent physical condition, and after admission to the hospital, a laparotomy was performed. The findings were exactly as previously described—a double colon from the cecum to the rectum (and vagina). The fistula was resected and closed, and an end to side anastomosis of the anomalous colon into the normal rectum was performed. The single normal right kidney was confirmed and no other anomalous condition was found at surgery. Except

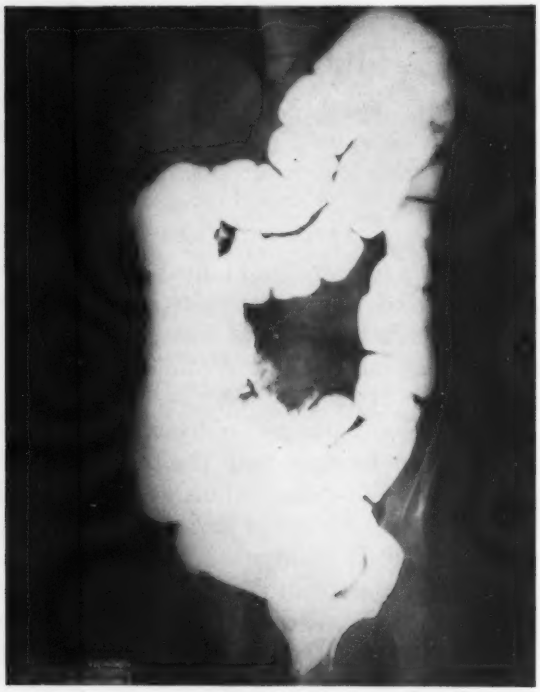

FIG. 1. Filled colon prone showing the reduplication of the transverse segments of the two colons.

for a mild transfusion reaction later on the day of surgery, the patient recovered uneventfully. She was discharged asymptomatically the eighth postoperative day.

Six months postoperatively, the patient was asymptomatic and had gained several pounds.

EMBRYOLOGY

Developmental anomalies associated with the peritoneal cavity are urogenital cysts, dermoids, teratomata, and lymphatic cysts. The anomalies confined to the gastrointestinal tract include duplications (or reduplications), giant diverticula, diverticula associated with the presence of pancreatic tissue and cyst-like diverticula. These examples of heterotopia are usually associated with the midgut, and in a series of 102 cases, Hudson[10] found only 18 of them to be actual reduplications of the gastrointestinal tract and of these only 3 were in the colon. These congenital anomalies are actually identical in structure with the bowel with which they are in intimate association. They have a mucosa, submucosa, circular and longitudinal muscularis, and a serosa. Occasionally, a common musculature is found. By far the most common type is found in the ileum, and of these the Meckel type composes the great majority. The relatively small group which is associated with the large intestine is the subject of interest in this paper.

There are several theories as to the formation of duplications. Hudson[10] gives the most thorough discussion on this subject. The most plausible theories are as follows:

1. Atavism as an example of reversion to a more primitive type. There are certain phylogenetically lower animals that have double ceca. There are none, however, that have a double midgut. This theory, therefore, cannot explain the considerable number of diverticula or cysts of the small intestine.

2. Persistence of vitelline duct. This would explain the commonly seen Meckel's diverticulum, but Edwards'[5] case was a duplication of a segment of terminal ileum which also had a Meckel's diverticulum

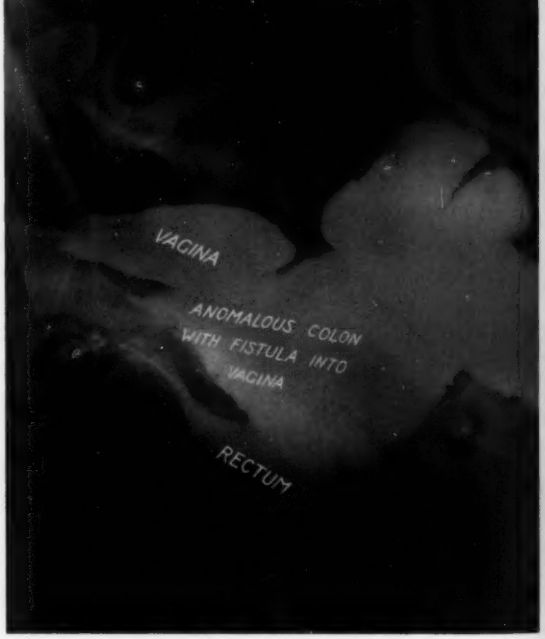

FIG. 2. Lateral film of the pelvis showing the anomalous colon with its fistula into the vagina.

associated with it. It would be impossible to have two Meckel's diverticula in one patient unless there was a concomitant duplication of the entire small intestine. Therefore, this is not a logical explanation.

3. The nodules of Lewis and Thyng. These investigators found nodules in young pigs, rabbits, and human embryos intimately associated with the esophagus, stomach, and small bowel lumina. They postulated that these were enteric "rests" which normally disappear by incorporation into the lumen of the adjacent intestine. If these epithelial rests persist, they may form cysts in the gastrointestinal wall, with or without one or more communications with same. This is a logical theory to explain small enteric cysts or diverticula, but it is highly unlikely that the entire large intestine (particularly with associated double urethra and bladder as have been reported in 7 cases[16]) could be duplicated by the enlargement of one rest or the coalescence of many enteric rests.

4. An entirely explanatory theory for the gross duplications of long segments of the gastrointestinal tract is the twinning process described by Edwards.[5] Reduplications of growth are of all gradations from separate complete anatomical entities down through craniopagus, (thoracopagus, ischiopagus, etc.) and conjoined twins and monsters to teratomata (in which the property of proportionate growth is lacking).

Fig. 4. Postoperative film showing the double colon on the postevacuation view.

Fig. 3. Postevacuation film clearly showing the colon and its reduplication.

There appears to be some intra-uterine stimulus to the embryo (or ovum) which causes this duplication. The degree of completeness of the gross duplication is a function of the age at which the product of conception receives the stimulus. Thus separate twins undergo that stimulus very early, whereas the fetus with an arm protruding from the ischial region receives it relatively late. Since the entodermal anlage of the gastrointestinal tract is the same for all portions thereof, there is no

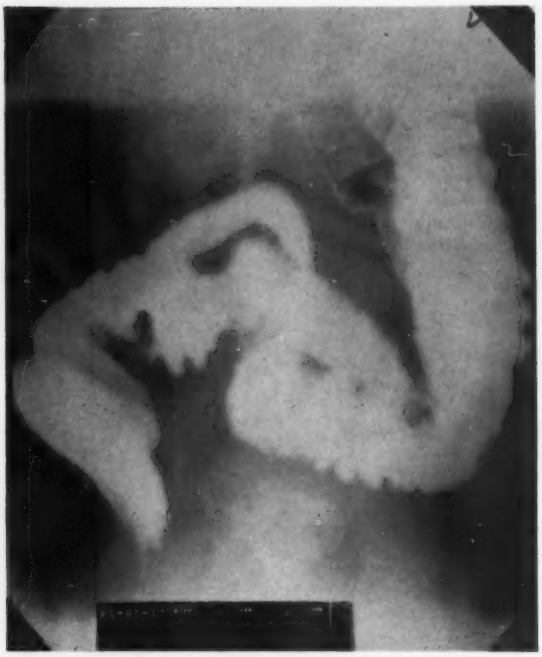

FIG. 5. Postoperative film showing the anastomotic site in the rectum.

reason why the proper stimulus applied rather late in embryonal development could not account for diverticula or duplications of the gastrointestinal tract. Experimentally the fertilized amphibian ovum has been divided at various stages of development and gross duplications from complete separate twins to gastrointestinal duplications have resulted. Needless to say, this is very important substantiating evidence for the twinning theory. Gray[8] and Diaz reported cases of triplication of the colon. It would be hard to explain this rare phenomenon except by this latter theory.

Van Zwalenburg[16] presented the seventh case in the literature of duplication of the entire hindgut, including the bladder and urethra. He tried to separate the reported cases of duplications of the colon into two types:

1. Those that accounted for the majority of the cases and were diverticula or duplications of all or part of the large intestine and produced symptoms by their size, obstruction, perforation, or bleeding; this type of duplication usually is found in the normal mesentery in a relatively dorsal position and could not be resected alone because of interference with the blood supply to the normal colon. Occasionally a separate mesentery existed.

2. The second type included duplications of the entire hindgut, urethra and bladder which followed a stimulus to twin during embryonal life. He felt that this latter group developed duplications of every part of the gastrointestinal tract, (including a separate mesentery) distal to the most proximal point of duplication because the embryonal growth proceeds in a caudad direction, and once the anlage of the gastrointestinal tract receives the stimulus to twin, everything caudal to the point of stimulus does so. He found that these cases were asymptomatic except when associated with developmental errors, such as imperforate anus or failure of development of the septum between the rectum and the urogenital sinus or when some unrelated disease was present.

FIG. 6. Intravenous pyelogram showing the absent left kidney.

DISCUSSION

The idea that twinning is the explanation for the smaller essentially nonsymptomatic group (versus the larger symptomatic group considered to be diverticula derived from an already developed hindgut) does not explain this case presentation. According to the above classification this case should fit into the larger group, which are only diverticula of an already developed hindgut and have no other anomalies except colon duplication, all or in part. The symptoms of this group are due usually to size, rotation, ulceration, or bleeding. However, the symptoms in the case presented were due to the fistula of the anomalous colon into the posterior vaginal wall, and there was another anomalous condition associated with it—congenital absence of of the left kidney. Since the latter originates from a separate anlage (genital ridge) from the hindgut, it would seem that there is a much more fundamental answer to the embryology than has as yet been advocated.

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RADIOLOGICAL VISUALIZATION OF THE BILIARY DUCTS WITH TELEPAQUE

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DURING the first half of 1953, we had the opportunity of testing oral telepaque in cholecystography. Telepaque, brand of iopanoic acid, is an oral cholecystographic medium which was also under study at that time by numerous authors in the United States.[7–17]

Christensen and Sosman[5] were the first to note that when using this radiopaque medium the cystic and common ducts were clearly delineated in several cases, after administration of a fatty meal. Later, Everett and Rigler,[7] Lowman and coworkers,[10] Stevenson,[15] Shehadi[14] and others confirmed this observation.

This discovery aroused our interest because we felt it meant great progress in the study of biliary tract pathology as against results obtained in cholecystography with iodoalphionic acid and other radiopaque media. Copleman[4] states that earlier cholecystographic procedures constituted an incomplete test at best since the extrahepatic biliary ducts were rarely, if at all, visible.

PROCEDURE

In this study telepaque was administered to 59 patients in doses of 3 to 6 grams, according to each individual's weight. An exact dose/weight relation, however, was not necessarily followed.

The day before the test the patient's diet was limited to fruit. The tablets (0.5 gm.) were given after lunch and dinner (3 and 3 for those taking a 3 gram dosage, or 3 and 6 for those taking a 4.5 gram dosage) or after breakfast, lunch and dinner (3, 3, and 6 tablets for those taking a 6 gram dosage).

Following the final telepaque dose, each patient entered upon a fasting period of twelve to fourteen hours, after which the series of cholecystograms were taken. It should be noted that approximately half an hour before beginning the test a cleansing enema was administered.

The first cholecystogram was taken with patient standing erect, under compression when necessary (i.e., suspected gallstone or gas surrounding the gallbladder shadow). Pitressin was used only in the presence of excess gas in the colon.

The fatty meal was then given. This consisted of a prepared formula containing egg yolk, peanut oil, and lecithin.

The patient was placed in a ventral and left anterior oblique decubitus and 15 minutes later a roentgenogram of the gallbladder area was taken. If the biliary ducts were not clearly delineated, we repeated

FIG. 1. Film obtained with telepaque, twenty-eight minutes after the administration of the fatty meal. (Case no. 32.)

Fig. 2. Twenty-five minutes after fatty meal. (Case no. 22.)

Fig. 4. Twenty-five minutes after fatty meal. (Case no. 45.)

Fig. 3. Thirty minutes after fatty meal. (Case no. 39.)

Fig. 5. Twenty-five minutes after fatty meal. (Case no. 54.)

FIG. 6. Twenty minutes after fatty meal. (Case no. 44.)

the exposures twenty-five, thirty, or thirty-five minutes after the fatty meal as needed (Fig. 1 to 6).

One hour after the meal, we took the final roentgenogram with the patient standing in the same manner as for the first roentgenogram. This was done for comparative purposes in order to ascertain the degree of gallbladder evacuation.

In view of the differences in side effects reported by various authors, we were careful to note every symptom and reaction. Scott and Simril,[13] for example, observed no diarrhea in a series of more than 300 patients, whereas Christensen and Sosman[5] report diarrhea in 8 per cent of their cases, and Morgan and Stewart[11] in 40 per cent.

RESULTS

The gallbladder shadow is more dense with telepaque than with other radiopaque media, and the comparative contraction in size before and after the fatty meal is much greater. In almost every case

TABLE I

VISIBILITY OF THE BILIARY DUCTS WITH TELEPAQUE

Good	Fair	Poor
28 cases	3 cases	2 cases
84.8 per cent	9.1 per cent	6 per cent

opaque residues were observed in the intestine, but they did not constitute any obstacle toward correct interpretation of the cholecystograms.

In Table I, the delineation of the biliary ducts is described as good, fair and nil on the basis of diagnostic value of the shadows. Cases of excluded gallbladder and cases of very weak density have been omitted. On the other hand, gallstone cases with good or fair telepaque concentration included a total of 33 patients.

Table II summarizes the side effects noted under identical conditions of administration in 89 patients using iodoalphionic acid and in 59 patients using telepaque. With telepaque the percentage of side effects is practically 50 per cent less in every category.

DISCUSSION

According to our experience, telepaque

TABLE II

SIDE EFFECTS

Contrast Media	Iodoalphionic Acid	Telepaque
Number of Patients	89	59
	Per cent	Per cent
Headache	32.5	8.4
Nausea	20.2	10.1
Vomiting	4.4	0.0
Abdominal pain	46.0	28.8
Diarrhea*	34.8	25.0
Sore throat	17.9	8.4
Dysuria	25.8	23.7
Motion sickness	6.7	3.3
Heartburn	3.3	1.6
General malaise	2.2	0.0
Acidity	2.2	1.6
Morning mouth unpleasantness	0.0	3.3

* Three or more intestinal movements in twenty-four hours.

is a very satisfactory cholecystographic medium. Tolerance is greater than for other radiopaque media and it gives useful information on the morphology of the entire extrahepatic biliary system. It produces very dense shadows and does not alter the gallbladder's shape or motility. In this respect, it is worth considering that in 1946, Copleman abandoned the use of iodoalphionic acid owing to its adverse influence on gallbladder evacuation, probably because of its sympathomimetic action. Misinformation on motility and lack of duct shadows has resulted in many unnecessary surgical operations, wherein gallbladders have been found to be normal (Dann and Koritschoner,[6] Feldman[8]).

It has been suggested that the dense opacity of telepaque can hide small stones. Nevertheless, Everett and Rigler,[7] Stevenson,[15] Whitehouse and Martin,[17] and Scott and Simril[13] do not concur in this opinion nor do we. In the rare cases where there may be some doubt, this possibility may be obviated by regulated compression as proposed by Åkerlund.[1,2] We have followed this procedure when it was considered necessary for many years with excellent results. Further, the routine procedure of making the first and last exposures with patient in erect position, using the serialograph, shows, even without compression, small stones that are not seen in the decubitus roentgenograms.

Fig. 7. Fifteen minutes after fatty meal. (Case no. 35.)

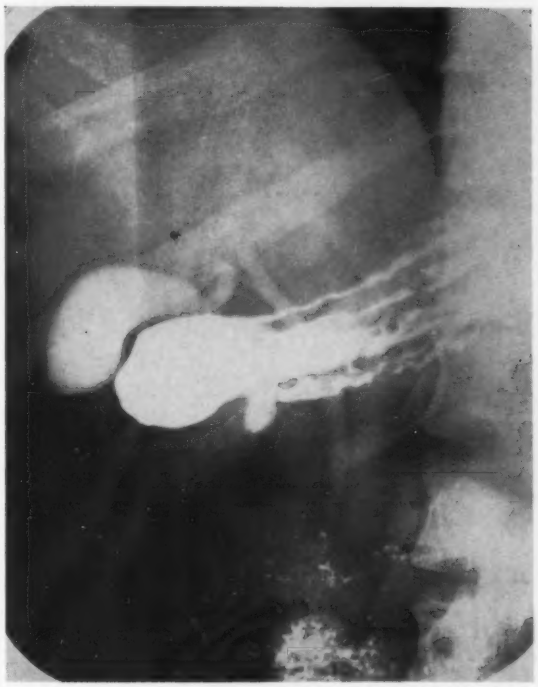

Fig. 8. Thirty minutes after fatty meal. Common duct diameter 6 mm. (Case no. 46.)

To get a clear picture of the biliary ducts, however, the erect position is inadequate. This is probably due to the effect of gravity on the viscera in general and on the contents of the common duct in particular. That is why we place the patient in ventral and left anterior oblique decubitus. Shehadi[14] has tested the dorsal decubitus position with the left side of the body lifted 10–15 degrees; the advantage of this position is affirmed by Renck[12] who states that the filling of the ducts can thereby be improved when the patient remains in that position for several minutes.

In our studies, the biliary ducts have shown up clearly in 85 per cent of the cases. This is a lower percentage than registered by Grugan[9] (91 per cent) but higher than

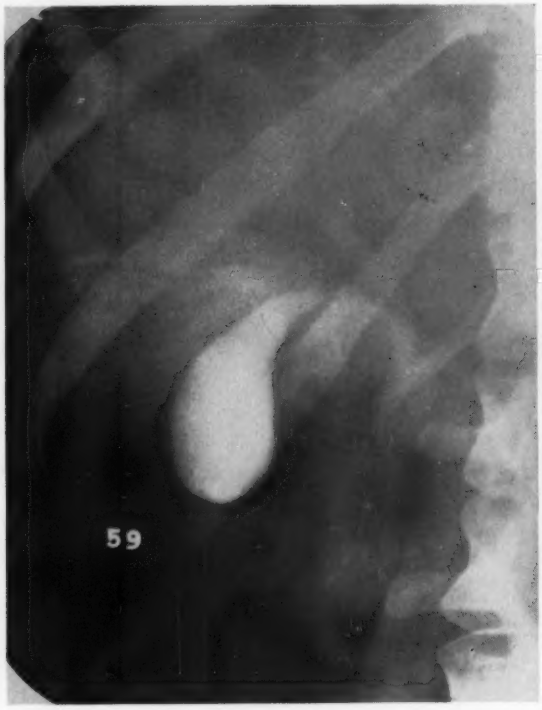

FIG. 9. Twenty minutes after fatty meal. Common duct diameter 8.5 mm. (Case no. 41.)

FIG. 10. Fifteen minutes after fatty meal. Common duct diameter 11 mm. (Case no. 13.)

that found by the majority of authors. Usually the diameter of the common duct (and also of the hepatic duct) was under 5 mm. (Fig. 7). In one case, however, it measured 6 mm. (Fig. 8), in another 8.5 mm. (Fig. 9), and in a third one, 11 mm. (Fig. 10).

We believe that in these 2 last cases the common duct was dilated beyond normal size, but we could not determine how much. Berk and his associates,[3] studying the results obtained with intravenous cholecystography and cholangiography, using Be 426, report a normal case in which the hepatic-choledochus diameter was 8 mm. Twiss and co-workers,[16] in a study on oral cholangiography with telepaque after cholecystectomy, state that, "The uppermost limits of the average postcholecystectomy bile duct shadow is provisionally considered to be approximately 6 mm. Diameters from 7 to 10 mm. are considered slight dilatation; those of 11 to 20 mm. moderate dilatation; over 20 mm. marked dilatation."

We do not know if these figures would hold for patients with gallbladder. Our experience is insufficient to advance definite statement in this regard. But we can affirm that it is now possible to diagnose pathologic changes in the extrahepatic ducts (in addition to the gallbladder) by means of a simple and safe technique, namely cholecysto-cholangiography with telepaque. It is not necessary to employ complicated methods with drugs that upset the physiology of the biliary tract. We share Grugan's[9] opinion that this is a technique which permits the radiologist to describe the shapes and anatomy of the cystic, choledochal and hepatic ducts.

SUMMARY

1. The results obtained with telepaque in 59 patients are described herein. The biliary ducts were clearly delineated with sufficient sharpness for diagnostic purposes in 84.8 per cent of the cases.

2. This oral cholecystographic medium produces dense shadows of the gallbladder,

without delaying evacuation of its contents as happens with iodoalphionic acid and other radiopaque media.

3. A comparative study of the incidence of side effects observed with telepaque and iodoalphionic acid shows a much higher degree of tolerance for telepaque.

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DIVERTICULA OF THE GALLBLADDER*

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DIVERTICULA of the gallbladder, Rokitansky-Aschoff sinuses or Luschka's crypts are present in approximately half of all gallbladders removed from persons more than thirty years of age,[11] but are rarely demonstrated by cholecystography. These sinuses, crypts or diverticula consist of invaginations of the gallbladder mucosa into the underlying layers of the gallbladder wall, occasionally as far as the peritoneal lining.

Although the demonstration of these structures by means of cholecystography is a rare occurrence, the recognition of this finding is important since it is characteristic and, moreover, is evidence of chronic gallbladder disease.

Since the original publication by March[10] in 1948 of visualization of the Rokitansky-Aschoff sinuses by cholecystography, additional cases have been reported by Ackerman,[1] Bean and Culver,[5] Akerlund and Rudhe,[3] Glucker,[6] Zinober,[16] Sukman and Daron,[13] and Robinson and Peters.[12] For a thorough historical review of this subject the reader is referred to the excellent report by Robertson and Ferguson[11] that traces the development of and the controversies engendered by this subject during the past three hundred years or more.

The terminology in itself is obscure and has led to much confusion even in the recent literature. Halpert[7,8] apparently was the first to use the term "Rokitansky-Aschoff sinuses" based on Rokitansky's description in 1842 of hernia-like out-pouchings of the gallbladder mucosa and the classic study by Aschoff on the pathologic anatomy of cholelithiasis and cholecystitis (1905). On the other hand, Robertson and Ferguson feel that Luschka (1858) observed and described the invaginations of epithelium into the wall of the gallbladder that later were called Luschka's crypts and if any man's name should be attached to these structures, it should be his by reason of priority in identification and description of their chief features. These authors feel that there is little except custom to justify calling them by any man's name and prefer to use the descriptive name—diverticula. In the American radiological literature, the term Rokitansky-Aschoff sinuses has been used most frequently since March's contribution although Vastine[14] reported visualization by cholecystography of a single calculus-containing diverticulum of a gallbladder in which Rokitansky-Aschoff sinuses were identified by the pathologist.

In the cases previously reported and those to be described below certain roentgen findings are consistent and can be considered characteristic, namely:

1. The presence of an interrupted rim of contrast material somewhat resembling a string of beads of slightly different size and slightly irregular shape, closely surrounding but separate from the main gallbladder shadow. These may or may not be seen in the films made before the gallbladder contracts; they are always present after the gallbladder contracts. If present before contraction, they are increased in number, size and density after contraction.

2. The presence of a stricture in the region of the neck of or upper part of the body of the gallbladder causing the gallbladder to appear as two separate components one above the other. Following the stimulus of fat, the superior segment exhibits considerably more contraction. This feature was noted by many authors.[5,10,12,13] Although not described by either Ackerman[1] or Zinober[16] it is fairly apparent from the illustrations in their articles that this feature was also present in their cases.

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Fig. 1. Case 1. (*A*) Film of the gallbladder before contraction showing segmentation. (*B*) Film made after the administration of cholex (slightly magnified in comparison to *A*) showing ring of diverticula surrounding lower segment. The contraction in the upper segment is relatively greater than in the lower segment. (*C*) Gross surgical specimen showing area of narrowing in the neck of the gallbladder. Probe points to opening of diverticulum or Rokitansky-Aschoff sinus.

REPORT OF CASES

Case 1. B.Y. This Japanese female, aged twenty-two, was admitted on January 18, 1954 with a history of sharp colicky pain in right upper abdomen radiating to right shoulder and occurring intermittently over a pe-

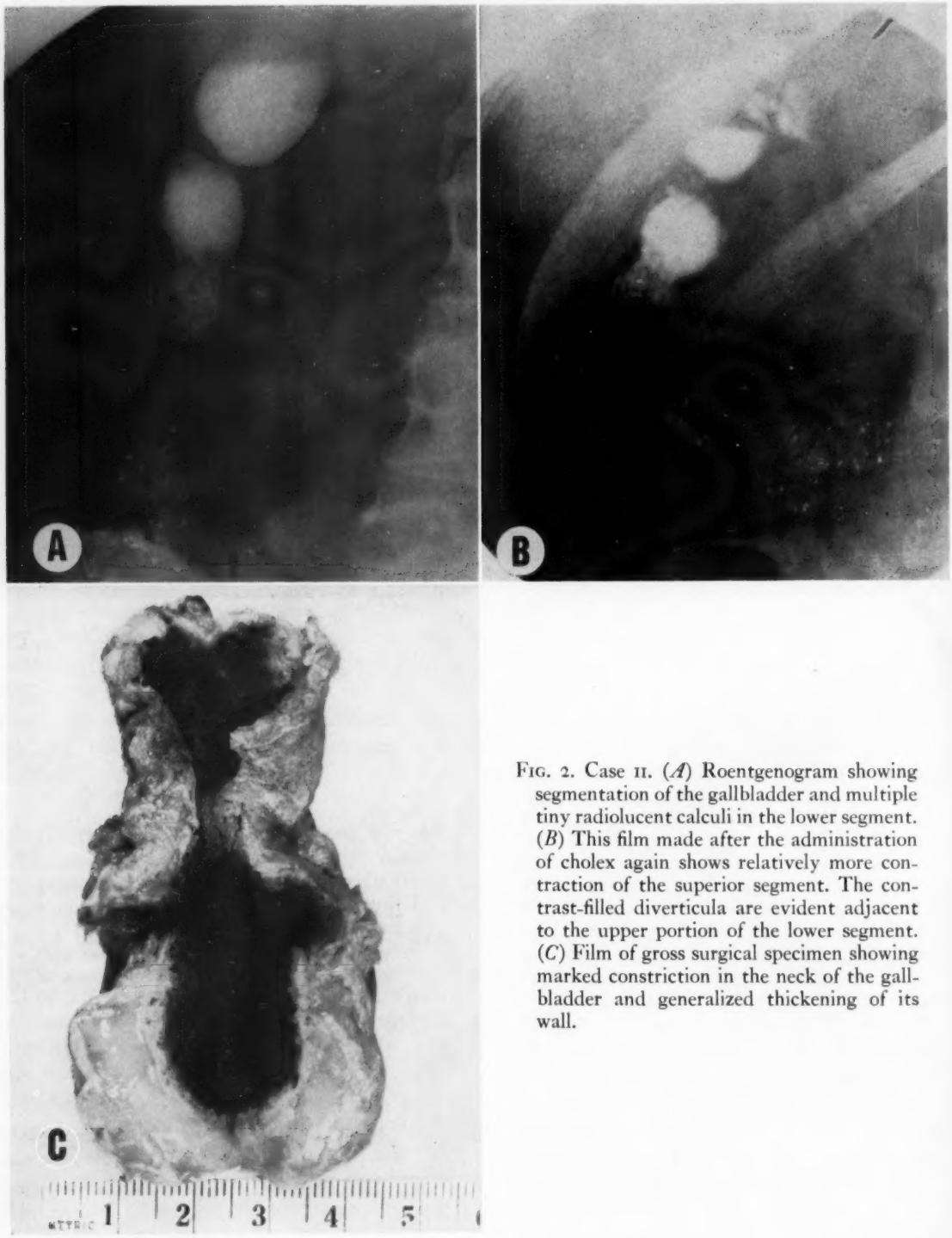

Fig. 2. Case II. (*A*) Roentgenogram showing segmentation of the gallbladder and multiple tiny radiolucent calculi in the lower segment. (*B*) This film made after the administration of cholex again shows relatively more contraction of the superior segment. The contrast-filled diverticula are evident adjacent to the upper portion of the lower segment. (*C*) Film of gross surgical specimen showing marked constriction in the neck of the gallbladder and generalized thickening of its wall.

riod of two days, one month before admission.

Cholecystograms made at that time and also on admission showed good concentration of the contrast material in a segmented gallbladder with no evidence of calculi. Following the administration of cholex, the upper segment contracted well; the lower segment only slightly. Surrounding the lower segment was

a ring of small opacities representing contrast material in diverticula or Rokitansky-Aschoff sinuses. Past history and family history were noncontributory.

Physical examination revealed only slight tenderness on deep palpation of the right upper abdomen. Laboratory findings showed nothing abnormal.

On January 19, 1954 a markedly thickened and edematous gallbladder was removed.

Microscopic pathology by Dr. Raid Chappell. " . . . Sections taken across or lengthwise to the segment of annular stenosis show normal wall running along up to a point where there is an abrupt increase in thickness of the muscularis with hypertrophy of muscle fibers. Sharply at this same point is the first of numerous Rokitansky-Aschoff sinuses. There is no evidence of fibrosis in the area of stenosis. There is chronic inflammation present of more than the usual amount and unusually severe edema of the outer portion of the gallbladder wall."

The patient made an uneventful recovery and was discharged on the ninth day.

Case II. D.M. A Filipino female, aged thirty-nine was admitted on March 2, 1954 with onset of intermittent, sharp, right upper abdominal pain two weeks before admission and continuing to present. The pain was accompanied by nausea but there had been no vomiting. Past history and family history were not contributory. Physical examination was essentially negative. Routine laboratory studies showed an icterus index of 13.2 (normal value 4–6) but otherwise were within normal limits.

Four days prior to admission cholecystography following the administration of six tablets of telepaque showed good concentration of the contrast material in a small segmented gallbladder. The lower and larger segment had an hour-glass configuration and in the lower compartment were multiple tiny radiolucencies interpreted as nonopaque calculi. Approximately 1 cm. separated the larger inferior segment from the much smaller superior segment. Films made at intervals following the administration of cholex showed contraction of both segments although the upper segment contracted considerably more. In these films there was noted adjacent to the inferior segment, particularly on its medial aspect, a chain-like arrangement of tiny opaque dots typical of contrast material in diverticula or Rokitansky-Aschoff sinuses.

Cholecystectomy and exploration of the common bile duct were performed on March 3, 1954.

Microscopic pathology by Dr. Raid Chappell. " . . . . There is marked edematous thickening of the gallbladder wall and severe hypertrophy of muscle fibers. There is no evidence of fibrosis in the area of annular stenosis or elsewhere. There are numerous Rokitansky-Aschoff sinuses some of which are cystically dilated and filled with inspissated bile. There is more than the usual amount of chronic inflammation present."

The patient was discharged in good condition on the eleventh day after admission.

DISCUSSION

According to Robertson and Ferguson[11] anatomically normal gallbladders contain few diverticula; when present they tend to be superficially located. Increased intracystic pressure, as evidenced by thickening of the gallbladder wall, absence of muscularis mucosae, a loosely, irregularly arranged muscle layer and the independent response of the muscle bundles to physiologic stimuli account for the initial diverticula-like indentations. The invaginations of the epithelium progress, sometimes as far as the peritoneal surface, and diverticular spaces with branching pouches are formed, occasionally simulating mucous glands when seen in cross section. This has given rise to the misleading terms "adenoma," "polyp," "cystadenoma," "cholesterol cysts," "papilloma," "cholecystitis glandularis proliferans (cystica),"[9] etc.

These diverticula are lined with epithelium corresponding in every respect to that which lines the mucosal surface of the gallbladder. These cells secrete mucus or a mucous-like fluid. Most of the diverticula open into the lumen of the gallbladder by ducts which are often tortuous and narrow. Some authors feel that this accounts in part for the rarity of their visualization by cholecystography. Except for the complexity of their branches, these diverticula cor-

respond in every way to the so-called false diverticula of the colon and urinary bladder.

The deeply penetrating, completely branching invaginations may be partially or completely cut off from the surface and become dilated to form cysts. Typical gallstones may be observed in the diverticula,[14] some completely closed off from the lumen and others which may be expressed into the lumen through ducts. Occasionally bile pigments and irregularly arranged collections of cholesterol crystals may be observed but as a rule the crypts contain mucin-like fluid. All degrees of inflammation leading to abscess formation, complete obliteration of the epithelial cells that normally line the spaces, or even rupture into the peritoneal cavity or the liver may and do occasionally occur. However, as a rule anatomic signs of inflammation are entirely absent in the diverticula and there is little reason to conclude that infection or irritation plays anything except a secondary role.[11]

It is interesting to speculate upon the "stricture" of the midportion gallbladder observed in the roentgenograms. To my knowledge this has not been described by the pathologists writing on this subject although, as stated previously, it has been a consistent roentgen finding. March interpreted it as a congenital stricture since there was evidence of a congenital anomaly of the kidney in his case. Bean and Culver stated that the constriction in their case appeared to be a localized thickening of the wall at the neck of the gallbladder probably due to the presence of large macroscopic sinuses containing pigmented concrements. They suggested that the stricture played a leading part in the production as well as the visualization of the sinuses in both cases. In Sukman and Daron's case there was a greatly thickened and narrowed ampullary portion which they felt was presumably the basis for the sequence of events resulting in the pathological findings.

It is possible that the "stricture" visualized by cholecystography may represent a localized segment of excessive hypertrophy in generally hypertrophied muscle. It is a fact that the so-called muscular coat of the gallbladder is a unique structure. The only similar formation which remotely resembles it in complexity of arrangement is that of the muscle bundles of the urinary bladder. Longitudinal, oblique and circular layers have been identified, but so many variations in arrangement have been found that a coordinated picture applicable to all gallbladders does not seem possible. In addition it has been shown that muscular contractions of the gallbladder wall are not in the form of rhythmic peristaltic waves but are isolated and at first independent; in other words the contractions and relations of the muscles tend to be unsynchronized.

In view of these facts, it is not unreasonable to assume that localized and excessive muscular hypertrophy accounts for the "stricture" visualized in the roentgenogram. This assumption is strengthened when one considers the images of the gallbladder following the stimulus to contract; both segments contract but the upper considerably more than the lower. Also, the diverticula are usually visualized adjacent to the lower segment or stricture after contraction. If the "stricture" is composed of excessively hypertrophied muscle, then contraction would tend to close this segment to a small opening causing lessened emptying of the lower compartment. The increased intracystic pressure resulting in the lower compartment would account for the greater number of diverticula in its wall. Localized and excessive muscular hypertrophy was found at the site of annular constriction in Case I, but not in Case II. It is noteworthy that there was no evidence of fibrosis at the site of constriction.

The cause of the disparity between the common occurrence of the diverticula in pathologic specimens and the extreme rarity of visualization during cholecystography is also an interesting subject for speculation. There is no uniformity of

opinion among the various authors who have written about this subject. Some[5,10,13] feel that it is due to impairment of concentrating power and reduced contractibility secondary to the usual association of these diverticula with chronic inflammatory changes. However, in these authors' cases the concentration was reported as good[13] and slightly less than normal[5,10] The contraction following a fatty meal was not mentioned,[5,13] but from the illustrations appears to be satisfactory, particularly of the upper compartment. In March's case, both pouches contracted, the upper more than the lower.

The explanation for the disparity of the pathologic and roentgenologic visualization of these diverticula or sinuses is probably due to a combination of both suggested causes.

SUMMARY

1. Diverticula (Rokitansky-Aschoff sinuses) of the gallbladder are discussed and two additional cases are presented in which they were visualized by cholecystography.

2. A theory on the formation of the compartmentation of the gallbladder, visualized particularly after contraction, is discussed.

3. It is reemphasized that the demonstration of diverticula of the gallbladder by cholecystography, while rare, produces characteristic findings indicating chronic cholecystitis.

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ADDENDUM

Since this article was submitted for publication, additional cases have been reported by the following:

Ross, W. D., Finby, N., and Evans, J. A. Intramural diverticulosis of gallbladder (Rokitansky-Aschoff sinuses). *Radiology*, 1955, *64*, 366.

De Angelis, C. E., and Miller, J. E. Rokitansky-Aschoff sinuses of gallbladder demonstrated roentgenographically; Report of case. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1955, *73*, 765.

FURTHER STUDIES IN MICRORADIOGRAPHY*†

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THE purpose of this paper is to present the roentgen appearance of the microscopic vascular pattern of several normal rabbit organs, after the arterial injection of a radiopaque medium. This report includes microradiographs of injected specimens of the stomach, jejunum, ileum, esophagus, ureter, thymus, skin, adrenal, ovary, fallopian tube, eye, lacrimal gland and uterus. In a previous paper we reported on the microradiographic appearance of the kidney, liver, spleen, gallbladder, duodenum and heart.[6]

MATERIALS AND METHODS

The method of microradiography used in this work was described previously.[6,7] A brief description of the procedure will be given here. The preparations were obtained by injecting live rabbits with a radiopaque solution of 10 per cent silver iodide with 3 per cent acacia of pH 8. Acacia was used to keep the colloidal particles in suspension. The pH 8 was suggested by Bentley[2] as a further aid. The injections were made through the arterial network, usually by means of a catheter in the aorta, at 150 mm. Hg. In some instances the organs were removed while the animal was still alive. In others it was found that better organ filling was obtained if the injections were continued after the animal expired. Sectioning was done after the intact organ was fixed in formalin for forty-eight hours. Most of the specimens were cut at approximately 300 μ by the frozen section technique. The section was then put between two layers of Stryafoil,‡ and placed on the photographic glass plate. We have found Kodak 548-0 emulsion to be very satisfactory. The roentgen equipment used was a

FIG. 1. Diffraction roentgen-ray unit. The tube is placed almost horizontally. A light-proof apparatus connects the plate holder with the tube window, providing an 8 inch distance. The plate holder is suspended and does not rest on the table, thereby diminishing any independent motion of either the tube or the photographic plate.

diffraction unit, with a chromium target and beryllium window. Figure 1 shows the unit, along with the apparatus used to hold the glass plate. The radiographs were made at 20 kv., 8 inch target film distance, 4 ma. with an exposure time of 1 to 3½ hours. The plates were developed in Kodak D 19 developer. Photographic enlargements were made from the radiographs by photomicrography.

The microradiographs presented in this paper were all made with the diffraction unit using the above technique. The method is essentially the same as that described by Barclay,[1] with some modifications. Other procedures have been described previously;[3,5] however, these

‡ Obtained from BX Plastics, London, England.

* This work was performed by the authors at the Caylor-Nickel Clinic, Bluffton, Indiana.
† Based on a paper presented by the authors at the meeting of the American Medical Association, Section on Radiology, Atlantic City, New Jersey, June 15, 1951.

were more complicated than Barclay's method.

The employment of low voltage with selected anodes of different types in microradiography makes use essentially of homogeneous radiation. Recently we[7] reported on a simplified method of microradiography using an ordinary diagnostic roentgen-ray unit with a tungsten rotating anode tube. Higher voltages up to 70 kv. were used. With this technique we were able to obtain microradiographs which could be enlarged satisfactorily to 75 times and sometimes more. This method depends more upon general radiation. Although the contrast in the microradiographs obtained with a tungsten target and higher voltage was less than with the diffraction unit, it was sufficient to permit fairly sharp differentiation of the injected vessels from the surrounding tissue.

RESULTS

The microradiographs included in this paper demonstrate the vascular pattern of vessels injected with a radiopaque medium. The particle size of the silver iodide used is such that it passes through the capillaries very slowly. The microradiographs obtained therefore demonstrate mainly the arterial and capillary circulation of each of the organs described.

Fig. 2. Esophagus ×25, cross section.

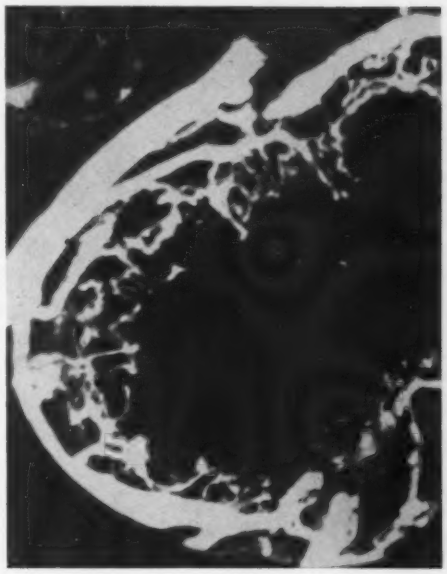

Fig. 3. Esophageal mucosa ×100, cross section.

Esophagus. A cross section of the esophagus is shown in Figure 2 enlarged 25 times. The lumen presents a stellate appearance. Larger vessels in the lamina propria follow the mucosal folds giving off smaller vessels which extend toward the mucosal surface. There is some filling of the submucosal vessels. A large vessel is present in the adventitia. Numerous branches extend through the muscularis to the submucosa. Further detail of the mucosal vessels is shown in Figure 3. Smaller vessels extend toward the mucosal surface. Some loop and return toward the base of the mucosa.

Stomach. The illustration (Fig. 4) at ×25 enlargement shows filling of the mucosa. The larger transverse vessels lie in the lamina propria. Branches are given off which enter the mucosa and run fairly straight and parallel courses to the mucosal epithelium. Other smaller branches follow the same pattern, but show more frequent branching. The subepithelial vascular pattern in the stomach is essentially the same as in the duodenum, jejunum and ileum. Numerous capillary loops are formed in this region. In Figure 5 (×25) a plexus of smaller vessels is seen in the muscularis and

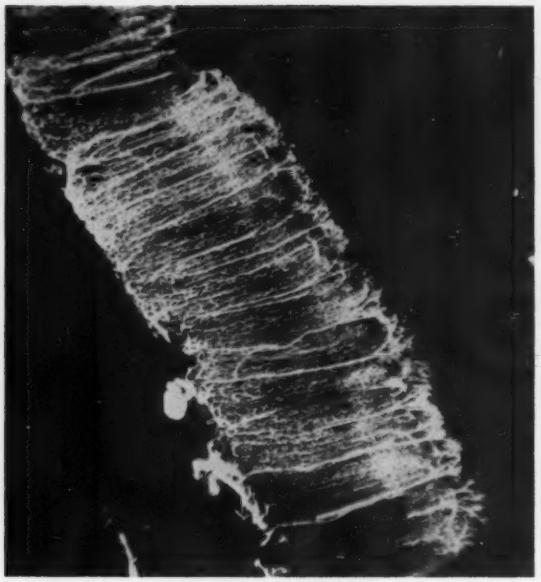

FIG. 4. Stomach mucosa ×25, cross section.

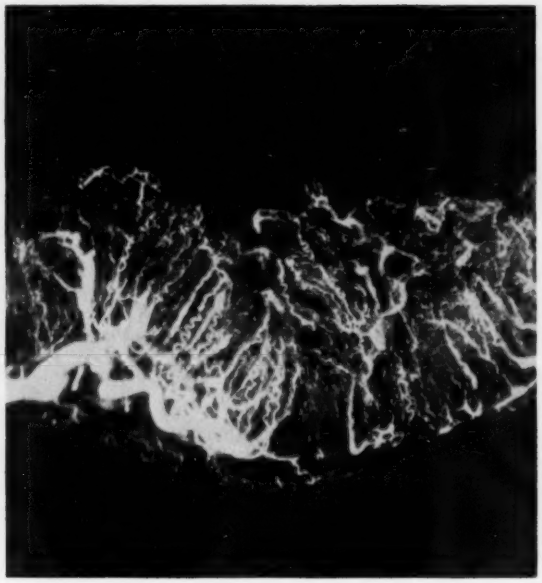

FIG. 6. Jejunum ×25, cross section.

serosa. The submucosa shows some irregular vessel filling.

Jejunum. A cross section of the jejunal wall is shown in Figure 6 (×25). It has the same general pattern that was seen in the stomach. Some vessels in the serosa and muscularis are filled. Branches from these pierce the muscularis to reach the submucosa. The distribution of the smaller arteries in the submucosa and mucosa is the same as in the stomach. Several vessels in the mucosa present a spiral appearance. Vessels of this type were also found in several other organs.

Ileum. Figure 7 demonstrates a cross section of the wall of the ileum. Large mucosal folds are present, containing many parallel vessels. These vessels extend into individual villi. The pattern of vasculature in the submucosa, muscularis and serosa is essen-

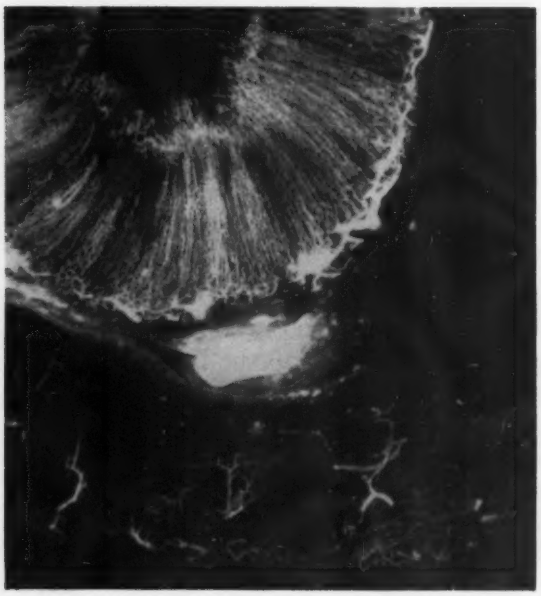

FIG. 5. Stomach ×25, cross section.

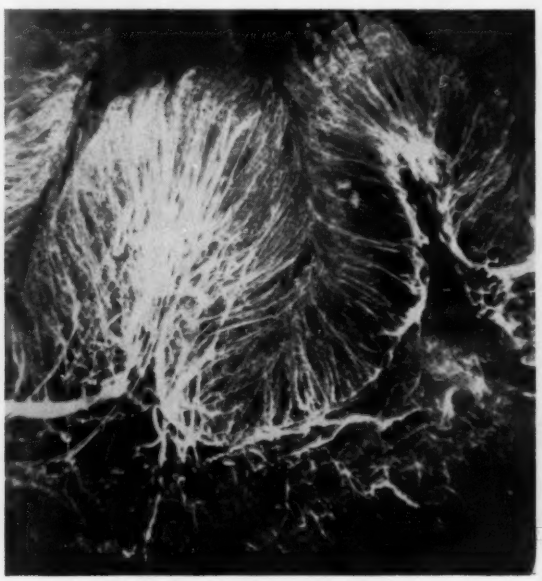

FIG. 7. Ileum ×25, cross section.

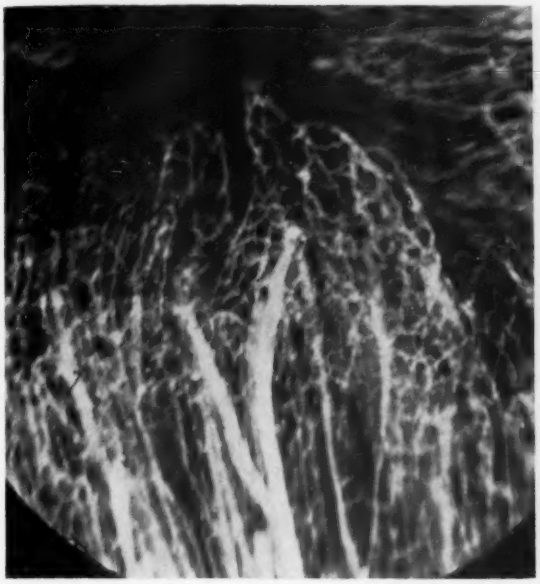

Fig. 8. Ileum ×100, mucosal surface.

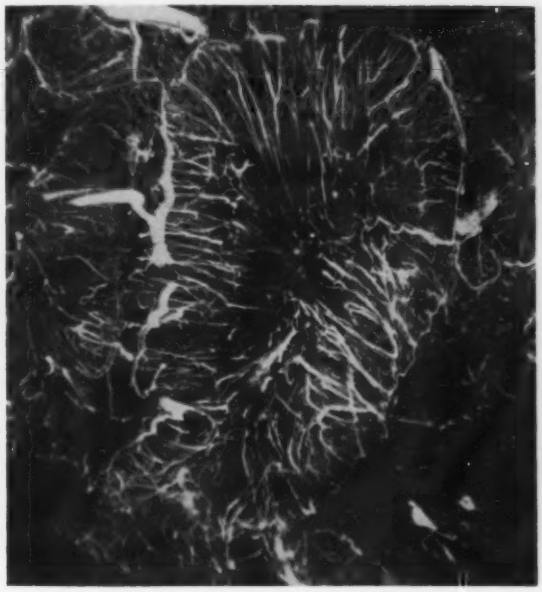

Fig. 10. Thymus ×25.

tially the same as in the stomach. Figure 8 demonstrates at ×100 enlargement, the capillary loops of the subepithelial area of the mucosa.

Adrenal. A cross section of the adrenal (Fig. 9) (×25 enlargement) demonstrates a difference in circulation of the cortex and the medulla. Larger vessels in the capsule encircle the gland. Smaller arterioles are seen in the cortex running toward the medulla in straight parallel courses. Occasional larger arterioles go directly to the medulla. The peripheral portion of the cortex shows more complete filling. The medullary vessels are small and run irregular courses.

Thymus. The thymus consists of lobules 1 to 2 mm. in width, separated by connective tissue septa. The lobules are continuous in the more central part of each lobe

Fig. 9. Adrenal ×25, cross section.

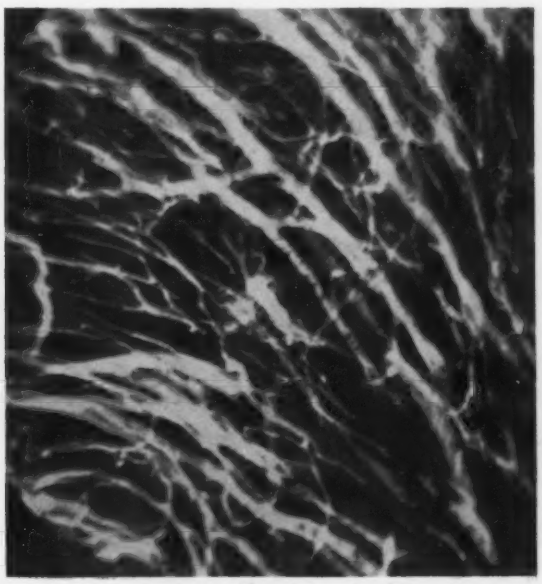

Fig. 11. Thymus ×100.

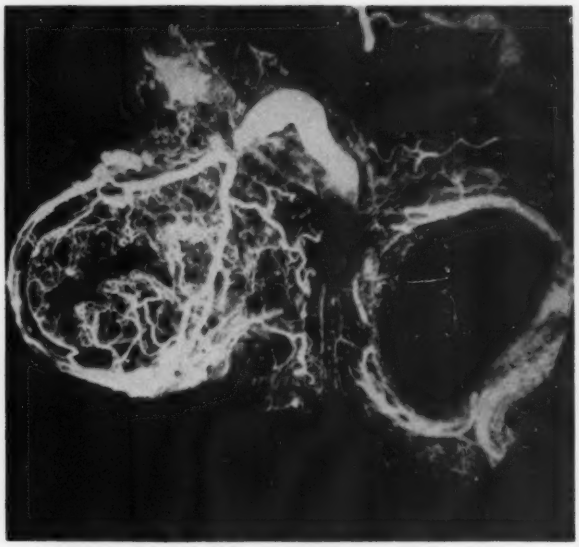

Fig. 12. Ovary and tube ×25.

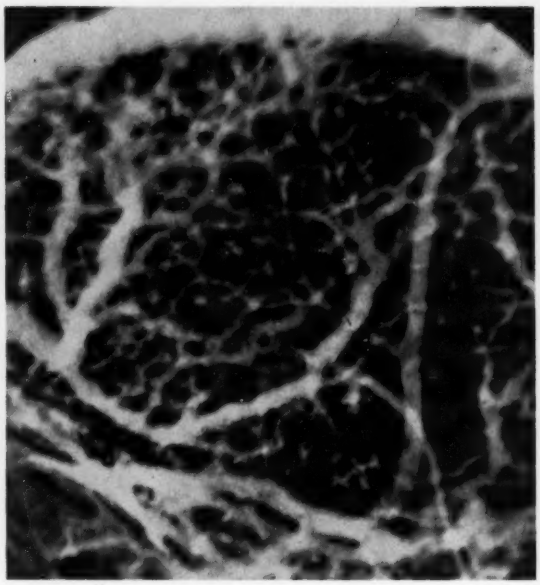

Fig. 14. Stroma of ovary ×100.

with the adjacent lobules. Figure 10 (×25 enlargement) demonstrates the vascular supply of a lobule. The lobule is surrounded by larger vessels which run around the periphery, giving off fairly straight vessels which run toward the center of the lobule. Figure 11 is a high power view (×100 enlargement) of the vessels of the peripheral portion of the lobule. Frequent branching is evident.

Ovary and Tube. The stroma of the ovary contains a dense network of blood vessels. This is shown in Figure 12 (×25 enlargement). Frequent anastomoses are present. A follicle is shown at the right. Rather dense vascularity is present about the periphery, probably in the theca interna. The uterine tube lies at the left in Figure 12. The outer circular vessels lie in the subserous coat. Branches pierce the muscularis

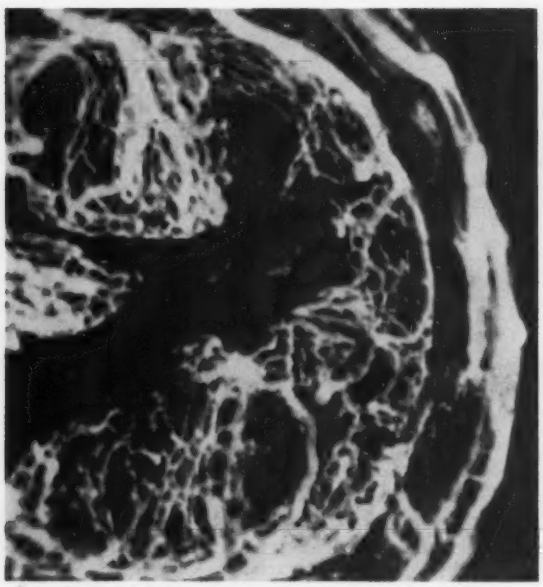

Fig. 13. Tube ×100, cross section.

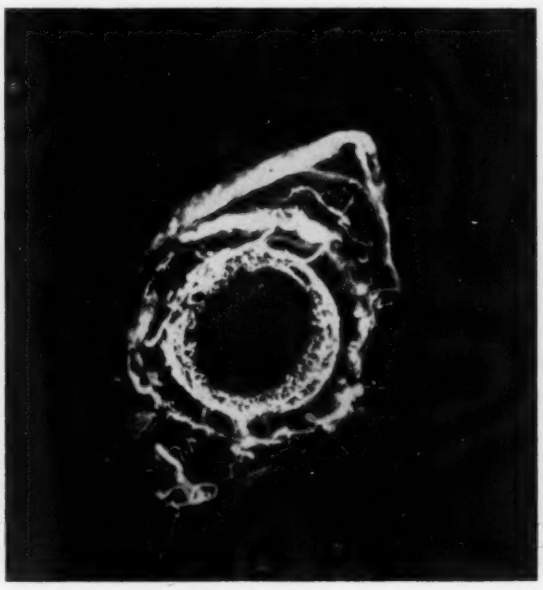

Fig. 15. Ureter ×25, cross section.

Fig. 16. Ureter ×100, cross section.

and extend to the second circularly disposed group of vessels which lie in the lamina propria and possibly the submucosa. The folds of the mucosa of the tube contain a rich anastomosing capillary plexus (Fig. 13) (×100 enlargement). Figure 14 (×100 enlargement) demonstrates the rich vascular plexus of the ovarian stroma.

Ureter. A cross section of the ureter (Fig. 15) (×25 enlargement) demonstrates a circular pattern of arterioles in the adventitia. Branches are given off which pierce the muscularis. Another circular layer is formed in the lamina propria. Capillaries leave these larger vessels and extend toward the mucosal epithelium where they anastomose (Fig. 16) (×100 enlargement). The vessels of the mucosa are shorter and broader than corresponding vessels of the gastrointestinal tract.

Skin. The skin of the back of the hind paw was injected via the femoral artery. A flat arterial plexus is present in the superficial part of the subcutaneous tissue (Fig. 17). Branches run more or less parallel courses in the corium going between the hair follicles. A capillary network is formed in its more superficial portion (right).

Iris. The iris (Fig. 18) (×4 enlargement) presents a pattern of vessels which arise from an arterial circle The vessels converge centrally toward the pupil and show diminishing caliber. Some of them loop and return in a peripheral direction. Occasional "corkscrew" vessels are seen. The vessels show anastomosis. Other vessels leave the arterial circle and extend peripherally. Figure 19 (×25 enlargement) shows the vessels of the iris near the pupil. The return loops are demonstrated.

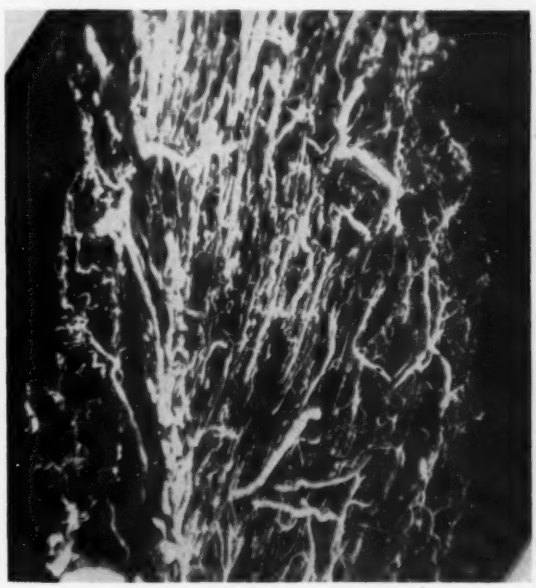

Fig. 17. Skin of posterior hind paw ×25, cross section.

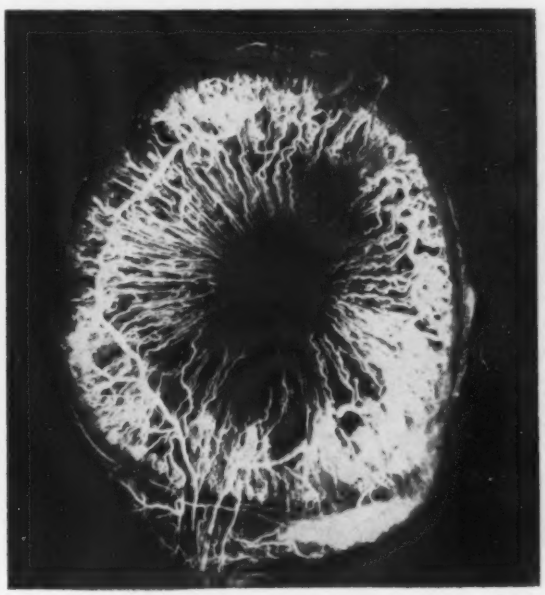

Fig. 18. Iris ×4.

Fig. 19. Iris ×25, pupillary portion.

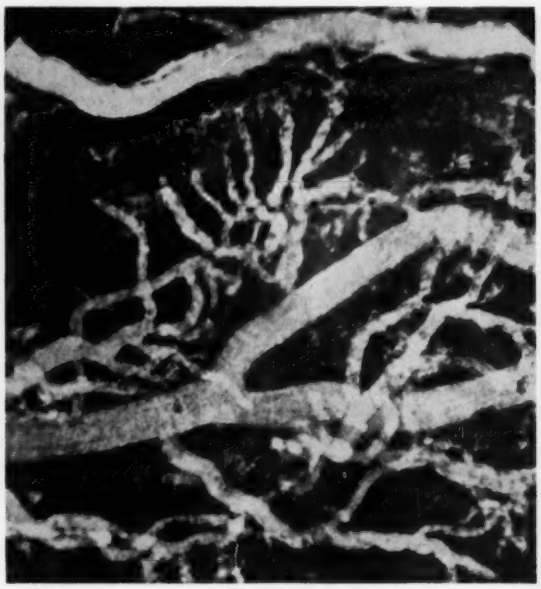

Fig. 21. Choroid ×100.

Choroid. The choroid layer of the eye (Fig. 20) (×25 enlargement) displays a pattern of parallel vessels which show frequent branchings. These arteries lie in the vessel lamina of the choroid. The smaller capillaries probably lie in the choriocapillary lamina. A higher magnification (×100) is shown in Figure 21.

Lacrimal Gland. The lacrimal gland is divided into a number of lobules. Larger vessels divide in tree-like branches which apparently supply the lobules. The capillaries show many anastomoses (Fig. 22) (×25 enlargement).

Uterus. Large vessels lie in the myometrium and the serosa (Fig. 23) (×25 enlargement). Large and small vessels run to the endometrial surface, showing frequent

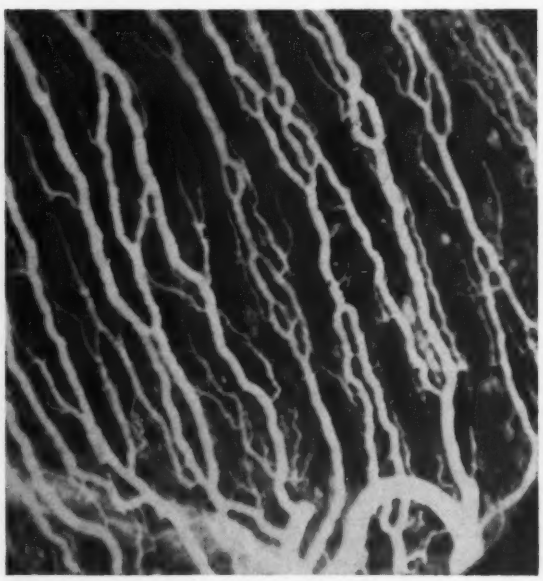

Fig. 20. Choroid ×25.

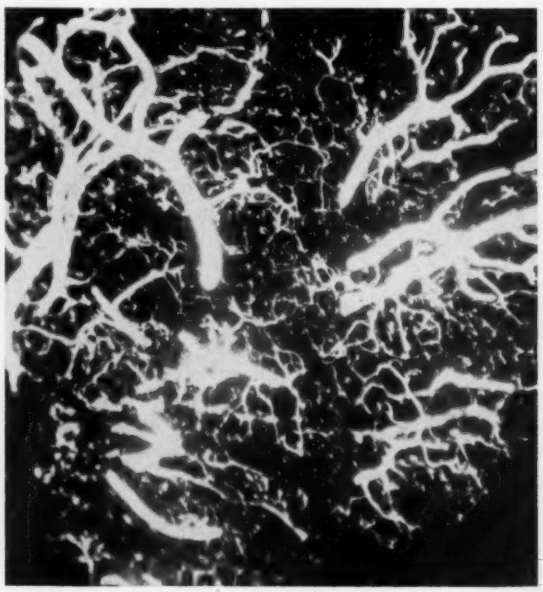

Fig. 22. Lacrimal gland ×25.

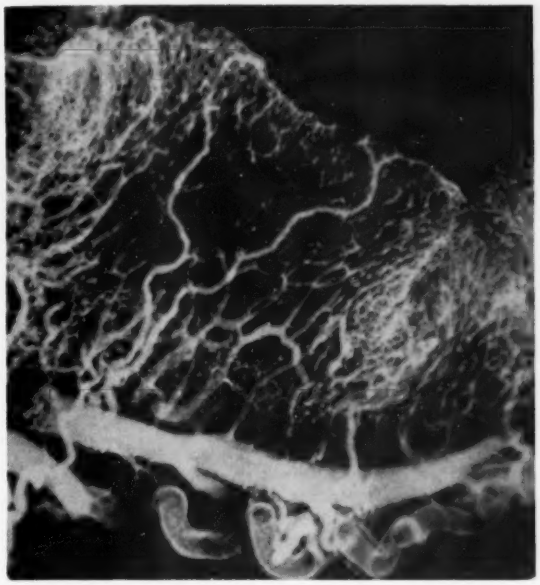

Fig. 23. Uterus ×25.

branching. "Spiral" arteries were seen occasionally in some of the microradiographs. These resembled similar arterioles in the iris and gastrointestinal tract.

DISCUSSION

The use of roentgen ray in the study of microscopic structures probably began in 1913. Engström[4] gives a survey of developments in this field to 1946. The microradiographic appearance of cell structure occupied the attention of workers in this field until the relatively recent work of Bohatyrtschuk in Europe and Barclay in England. These latter workers investigated the roentgen-ray appearance of the microscopic vascular distribution in tissues after the injection of radiopaque substances.

The field of microradiography is relatively undeveloped and we believe that it will prove to be an important aid in the study of normal and abnormal tissue. Microradiography, as a method of studying the vascular structure of injected specimens, presents several advantages.

The procedure of microradiography is relatively simple. Barclay[1] states, "It requires little skill beyond that of ordinary photographic competence, and can be carried out by an intelligent assistant when once the factors have been worked out." A three dimensional concept is obtained. The vessels can be studied in relatively thick sections many times thicker than ordinary microscopic sections. Long runs of vessels can be seen and their distribution in various tissues can be better understood. Each one of the tissues studied in this presentation and in our previous paper presents a vascular pattern that is distinctive for that organ. In fact, the organ from which the tissue was taken can be recognized as readily from the microradiograph as from the histological section.

CONCLUSION

The microradiographic appearance of the vascular pattern of the following rabbit organs has been presented: esophagus, stomach, jejunum, ileum, adrenal, thymus, ovary and tube, ureter, skin, eye (iris and choroid), lacrimal gland, and uterus. The vascular network of each organ as shown by microradiography presents a pattern that is distinctive.

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RADIATION IN THE THERAPY OF PEPTIC ULCER*

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IT IS now generally accepted that the presence of acid gastric juice is indispensable to the formation of chronic peptic ulcer; hence, measures influencing the secretion of acid may be of therapeutic significance. Control of the interdigestive phase of acid secretion is of particular importance, since the acid may remain unneutralized for relatively long periods of time. The rationale for the use of radiation therapy in peptic ulcer is that a depression of acid gastric secretion may facilitate the process of healing. Bruegel in 1917 was apparently the first to apply the method; since then isolated studies have appeared.[1,3] The purpose of this paper is to present a general review of results obtained in selected groups of patients with gastric or duodenal ulcer. The study has been a long-term experiment beginning in 1937 and continuing to the present time. The technique of irradiation has varied from period to period. A satisfactory evaluation is difficult for this reason and also for the additional reason that radiation has been used as an adjunct to standard medical therapy.

METHODS

The gastric ulcer group includes 116 patients observed during the period of 1937 to 1954. An adequate follow-up was obtained in 115 of these patients.

The patients with duodenal ulcer selected for this report were the 113 treated in 1945 and 1946. This group was selected primarily because of the dosage of radiation used and because the period of observation is almost ten years.

In both groups of patients, in addition to usual history, physical examination, gastric analysis, and examination of the feces for occult blood, objective evidence of ulcer was obtained by roentgen examination. In many patients with gastric ulcer the lesion was also identified by gastroscopy. In addition to the routine medical program of hospitalization, diet, milk and cream, antacids and in some patients gastric antisecretory drugs, therapy also included roentgen irradiation to the body and fundus of the stomach in an attempt to reduce the acid gastric secretion. In the gastric ulcer patients the total depth dose varied from 1,100 to 2,930 r. Most of the patients received 1,600–1,700 r. The reason for the variation of the dosage in this group is that the procedure has been on at least a partially experimental basis over the years. However, the patients with duodenal ulcer were treated uniformly, all receiving 1,600–1,700 r depth dose to the body and fundus of the stomach.

The present technique of radiation therapy is as follows: After the ingestion of 250 cc. of regular chocolate flavored barium water mixture, the outline of the stomach is marked on the skin under fluoroscopic control. The orthodiascopic method is used to insure accuracy and the patient breathes normally during the procedure. Marking is done in both prone and supine positions with the arms at the sides. Depending on the size and shape of the stomach 13 by 13 cm. or 10 by 17 cm. portals are now outlined over the gastric fundus. It is our practice to tatoo small marks in each corner using india ink. On the following day, after the barium has left the stomach, treatment is started. Both portals are treated daily thereafter for ten treatment days. The depth dose is estimated in a plane lying $\frac{1}{3}$ of the distance from the anterior surface of the body and $\frac{2}{3}$ the distance from the posterior surface of the body. Although the

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stomach may vary somewhat from this position, the change in depth dose from a point $\frac{1}{4}$ of the anteroposterior diameter to $\frac{3}{4}$ of the anteroposterior diameter is not more than 10 per cent with our factors. Using 250 kv., 25 ma., 50 cm. focus skin distance, 1 mm. Cu and 1 mm. Al filter (half value layer 1.5 mm. Cu) a skin dose is selected so that the combined daily contribution to the fundus from both portals provides a tissue dose of 160 r minimum. Thus in ten treatment days the gastric fundus receives a minimum tissue dose of 1,600 r. This has been repeated after a time interval of a year or more in selected cases.

A moderate number of patients experience nausea during the course of therapy. There is usually a mild erythema of the skin in the portal areas and in the larger patients this reaction is often quite sharp. No serious skin change has been seen even where the course has been repeated.

RESULTS

Gastric Ulcer. Since a detailed analysis of the results obtained in this group has been previously presented[2] only the highlights will be summarized here. Of the 116 patients there were 93 males and 23 females. Seventy-eight patients were followed five years or more. All the patients, except 14, were forty years of age or more when receiving therapy, 70 were between forty and sixty years of age.

Before irradiation all patients had had one or more recurrences on the usual diet and antacid program. After irradiation therapy, the recurrence rate was reduced for the entire group. The ulcer failed to heal in 6.7 per cent; 40 per cent did develop recurrent ulcer; 53.3 per cent have had no further recurrences to date. The question arises as to the factors most accurately reflecting or predicting the tendency to recurrences. In this series, neither the size of the ulcer nor site of the lesion bore any relationship to future recurrences. The female patients responded better than the male, 17.4 per cent of females had recurrences as compared with 44 per cent of males. On the whole, patients with shorter histories had lower recurrence rates. The prognosis appeared unchanged from decade to decade up to the age of sixty; after sixty, the outlook seemed more favorable.

Table I

RADIATION INDUCED ACHLORHYDRIA IN BENIGN GASTRIC ULCER

Duration of Achlorhydria	No. of Patients	Patients in Whom Ulcer Healed	Recurrence during Achlorhydria
Months			
1– 6	15	14	0
7–12	16	16	0
Years			
1–10+	10	10	0
Total	41	40	0

Probably the most significant indication of the effect of therapy is the postirradiation level of acid. In every patient in the present series hydrochloric acid was secreted in the stomach. In 41 patients irradiation produced a temporary achlorhydria (Table I). During this period complete healing occurred in 40. In no case did an ulcer recur during the period of anacidity; symptoms never reappeared during the phase of achlorhydria. In the one instance in which complete healing did not occur during the period of achlorhydria, the duration of the anacidity was brief; the ulcer healed subsequently in spite of the reappearance of acid. In 9 patients the achlorhydria persisted from eighteen months to thirteen years; in all of these, the ulcer healed and has remained healed to date (Table II). Prior to treatment this group had had symptoms with semiannual to biannual recurrences for periods varying from four to fifty years. In 34 patients a permanent reduction of gastric secretion of greater than 50 per cent was obtained. Only 5 of these patients experienced recurrences. In contrast to this, the acid secretion was not affected in 20 patients and in further contrast to the

TABLE II

INFLUENCE OF RADIATION-INDUCED ACHLORHYDRIA ON RECURRENCE RATE OF BENIGN GASTRIC ULCER

Duration Achlorhydria		After Beginning of Achlorhydria	
Duration of Symptoms Yr.	Recurrence rate	Duration Yr.	Recurrence
5	Annually	2	0
8	Every 6 mo.	1½	0
4	Every 2 yr.	5	0
4	Every 6 mo.	8	0
50	Annually	8	0
8	Every 6 mo.	6	0
10	Annually	6	0
4	Annually	6	0
9	Every 6 mo.	13	0

previous groups only 4 of these patients have not developed a recurrence to date (Table III). The over-all effect on the acid secretion in the gastric ulcer group may be summarized as follows: An immediate reduction in acidity of 50 per cent or more was obtained in 79 per cent of the patients. In 36 per cent the reduction lasted one year or longer; in the remaining patients the secretory rate returned to pre-irradiation level within three to twelve months. In 9 per cent of the patients an apparently permanent achlorhydria developed. The decrease in secretion usually occurred within four to six weeks after completion of the radiation.

Forty-five of the 116 patients had as complication hemorrhage or previous acute perforation; 3 experienced more than one complication; the most frequent was hemorrhage (42 patients). The rate of recurrent ulcer following irradiation therapy for gastric ulcer was no greater in the group with previous complications that it was for the total group. In the total group the incidence of recurrent complications was greatly reduced following irradiation. Of the 42 patients who had experienced hemorrhage prior to therapy only 4 had bleeding. Thus, of the 45 patients the incidence of recurrent complication was only 13 per cent (Table IV). Of the 46 patients who had recurrent ulcer, 12 underwent operation, 21 were again treated with antacids and 12 received a second course of roentgen therapy. One patient died of a perforated ulcer, to our knowledge the only death due to ulcer in the series. Of the 12 patients who received a second course of therapy, 4 have had no recurrences to date. Of the 21 patients who continued on a medical program alone 12 have had no further difficulty.

TABLE IV

RELATIONSHIP OF COMPLICATIONS TO RECURRENCE OF BENIGN GASTRIC ULCER

Complications	No. of Patients with complications	No. of Recurrences		No. of Ulcers not Healing
		Uncomplicated	Complicated	
Hemorrhage	39	15	4	6
Hemorrhage and perforation	3	1	0	0
Perforation	3	0	0	0
Total	45	16	4	6

TABLE III

RELATIONSHIP OF POSTRADIATION ACIDITY TO RECURRENCE OF BENIGN GASTRIC ULCER

Effect of Gastric Secretion	Total No. of Patients	Failure of Ulcer to Heal	Recurrence	No Recurrence to Date
Reduction in acidity by less than 50 per cent	20	2	14	4
Reduction by more than 50 per cent for less than one year	41	2	25	14
Reduction by 50 per cent or more for one year or more	34	0	5	29
Total	95	4	44	47

Table V

RADIATION INDUCED ACHLORHYDRIA IN DUODENAL ULCER

Duration of Achlorhydria	No. of Patients	Pt. in Whom Ulcer Healed	Recurrence during Achlorhydria
Up to 6 mo.	15	15	0
6 mo. to 1 yr.	4	4	0
1–5 yr.	6	6	0

Thirty patients (26.8 per cent) of the 116 eventually required surgery.

There have been no significant complications attributable to irradiation in any of the 116 patients with benign gastric ulcer. The incidence of neoplasm developing in the stomachs of patients with healed ulcers was 1.7 per cent, a figure almost identical with that obtained by Smith, Boles and Jordan,[4] and one to be expected on the basis of the anticipated frequency in the general population. One developed 14 years after irradiation and another 18 months after therapy. This low percentage suggests that neither the ulcer nor the radiation therapy had anything to do with the subsequent development of cancer. Of the eight other cancers detected in this group no significant relationship seems apparent, with the possible exception of three pancreatic neoplasms. We have encountered a number of pancreatic malignancies in patients with duodenal ulcer not treated with radiation therapy, and so are not impressed with the present findings.

DUODENAL ULCER

The 113 patients with duodenal ulcer treated in the years 1945–1946 have been followed a minimum of five and a maximum of nearly eleven years. Nineteen of the patients were women. Craters were demonstrated in 86, deformity in 95, and varying degrees of stenosis in 15. All had symptoms interpreted as those of active ulcer prior to therapy. Six suffered with intractable pain; 72 experienced night pain. The median duration of symptoms prior to therapy was eight years; 34 reported semiannual or annual pre-treatment recurrences of symptoms.

Histamine achlorhydria was induced in 25 (23 per cent) patients. This effect lasted up to six months in 15, and persisted from six months to five years in 10. In no instance did the ulcer recur during the period of achlorhydria (Table v). However, with return of acid secretion 8 of the 25 patients did develop recurrent ulcers. An additional 35 (34 per cent) patients had greater than 50 per cent reduction in the concentration of free hydrochloric acid. This effect, like the achlorhydria, lasted up to six months in two-thirds and persisted from 1 to 5 years in one-fourth. With increase in the acid concentration, recurrences occurred in 15 (Table vi).

Of the 113 patients 38 experienced recurrences. These were diagnosed on the basis

Table VI

RELATIONSHIP OF POSTRADIATION ACIDITY TO RECURRENCE OF DUODENAL ULCER

Effect on Gastric Secretion	Total No. of Patients	Failure of Ulcer to Heal	Recurrence	No Recurrence to Date
Reduction in acidity by less than 50 per cent	53	2*	20	31
Reduction by more than 50 per cent for less than one yr.	45†	0	13	32
Reduction by 50 per cent or more for one yr. or more	15†	0	5	10
Total	113	2	38	73

* No acid studies available, operation immediately after radiation therapy.
† Includes patients with achlorhydria.

TABLE VII

INTERVAL BETWEEN HEALING AND RECURRENCE OF DUODENAL ULCER

Years	No. of Patients
0– 1	13
1– 3	6
3– 5	7
5–11	12
Total	38

TABLE VIII

COMPLICATED DUODENAL ULCER. RECURRENCE OF PAIN AND COMPLICATION AFTER THERAPY

Complication	Prior to Therapy	Following Therapy No. of Recurrences	
	No. of Patients	Pain Only	Complication
Hemorrhage	34	7	4
Perforation	3	1	0
Total	37	8	4

of crater as seen roentgenologically, the finding of an ulcer at operation, the appearance of further complications of ulcer disease, or in a few instances only on the basis of recurrence of the typical symptoms. Thirteen recurrences developed within the first year; six took place the next two years; seven between the third and fifth year, and twelve between the fifth and eleventh year of follow-up (Table VII).

Prior to irradiation 34 patients had had 37 hemorrhages. Four of these had hemorrhage after therapy. Three patients had perforations prior to treatment; none of this group has experienced perforation following therapy (Table VIII).

Surgery was performed in 18 of the 113 patients because of recurrent ulcer. One additional patient refused operation. Two of the patients operated upon immediately after irradiation because of obstruction obviously should have been treated initially by surgery rather than irradiation. Perhaps a similar comment is valid with respect to 3 additional patients who were subjected to operation within six months of irradiation because of obstruction. Obstruction was the indication for operation in 7 other patients, 2 of whom had associated bleeding at the time of surgery. The six remaining operations were performed for recurrent ulcers one to eight years after irradiation. All of these patients have been well since surgery.

Eight patients have died since their therapy in 1945 or 1946, but in none was the death directly or indirectly attributable to ulcer with the possible exception of one death from an unknown cause. Three deaths were due to hypertensive or arteriosclerotic heart disease. One patient died from a prostatic condition and the other a metastatic neoplasm in the brain thought to have been primary in the lung but the site of the primary lesion remained undetermined.

SUMMARY

This is an admittedly brief report of a study on the use of radiation therapy as an adjunct in the treatment of peptic ulcer. The techniques and dosages varied in the group of 116 patients with gastric ulcer treated over a period of 17 years; the technique and dose were constant in the 113 patients with duodenal ulcer treated in the years 1945 and 1946. The over-all results with respect to effect on gastric secretion, healing and recurrence of the ulcer, recurrence of complications, and incidence of undesirable effects have been analyzed as carefully as possible. A reduction in gastric acidity in most patients for varying periods of time has been demonstrated with achlorhydria also for variable periods of time in a small number of patients. In no instance did an ulcer fail to heal when achlorhydria was produced for three months or longer, nor was there recurrence during such a period of achlorhydria. In the gastric ulcer group, 53 per cent have had no recurrence to date; 27 per cent have been subjected to surgical treatment. In the duodenal ulcer group 66 per cent have had no recurrence

to date; 16 per cent have been subjected to operation. The indication for operation in two-thirds of those submitted to surgery was recurrence with obstruction. In 39 patients with massive hemorrhage secondary to gastric ulcer, there have been four instances of massive hemorrhage following therapy. In 34 patients with duodenal ulcer with hemorrhage prior to therapy, there have been four recurrent episodes of bleeding. Acute perforation subsequent to therapy has not yet been observed in either group of patients. No significant complications or sequelae of radiation therapy were noted in this series.

CONCLUSION

Radiation therapy to the body and fundus of the stomach is a safe and useful adjunct to the medical management of peptic ulcer.

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ROENTGEN SIMULATION OF POLYPOID NEOPLASMS BY INVAGINATED APPENDICEAL STUMPS*

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ROENTGENOGRAPHIC abnormalities characterisitic of polypoid lesions are not infrequently observed in well executed examinations of the colon, especially when air contrast studies are routinely made. In the cecal region, a variety of lesions and pseudolesions may simulate and must be differentiated from true polypoid adenomas. Among these are prominent ileocecal valve lips, resinous fecal clumps, submucous lipomas, and defects arising from adjacent inflammatory or neoplastic masses such as appendiceal or ileal granulomas, appendiceal mucoceles, carcinoids, carcinomas, etc. Although several publications have called attention to the roentgen defects caused by invaginated appendiceal stumps,[1,2,4,5,6,7] this entity does not seem generally recognized, and the significance of the close roentgenographic resemblance of these pseudolesions to true adenomas may not be fully appreciated. The following case reports will serve to illustrate the features and implications of such findings.

CASE I. N.B., a man, aged forty-two, was operated upon by M.H.R. at St. John's Hospital, Santa Monica, California, on May 10, 1951, for acute appendicitis. The appendix was found to be acutely inflamed, retrocecal in position and bound down posteriorly. The appendix was removed in a retrograde fashion and its stump was inverted into the cecum without ligation. The serosa and muscularis of the cecum were sutured over the invaginated appendiceal base. Recovery was uneventful.

Because of intermittent rectal bleeding of nine years' duration, a barium enema pneumocolon examination was carried out in February, 1953. An intraluminal defect was found at the tip of the cecum (Fig. 1). Although this defect was believed to represent the inverted appendiceal stump, the possibility of an adenoma arising in this location could not be excluded with certainty. A second operation was therefore performed in April, 1953, at the Cedars of Lebanon Hospital.

At operation, a small polypoid mass was palpated through the cecal wall near its tip. The cecum was opened and the portion of its wall from which the mass arose was excised.

Grossly the lesion consisted of a 2.5 cm. circle of indurated tissue surfaced by pink mucosa displaying slight puckering (Fig. 2).

Microscopically there was a mound of tissue surfaced by colon mucosa displaying inflammation and submucosal follicle formation. There was cicatrization of the submucosa and distortion of the muscular layer.

The pathologic diagnosis was cicatrix (appendiceal stump) of the cecum.

CASE II. K.K., a woman, aged forty-three, complained of attacks of severe right lower quadrant abdominal pain. Laparotomy was performed on July 25, 1949, by Dr. David Rosenblum. The serosal vessels of the appendix were found to be markedly injected. No other abnormalities were observed. Appendectomy was carried out and the stump of the appendix was inverted into the cecum without ligation. The serosa and muscularis of the cecum were sewn over the invaginated appendiceal stump. The patient made an uneventful recovery and remained asymptomatic thereafter.

As part of a routine examination done in March, 1953, because an identical twin of this patient had developed an ovarian carcinoma, a barium enema pneumocolon examination was done and repeated for confirmation. These studies revealed a filling defect in the cecum, (Fig. 3).

Operation on April 27, 1953, by M.H.R. disclosed a nodular mass at the site of the previous appendectomy. The cecum was opened and

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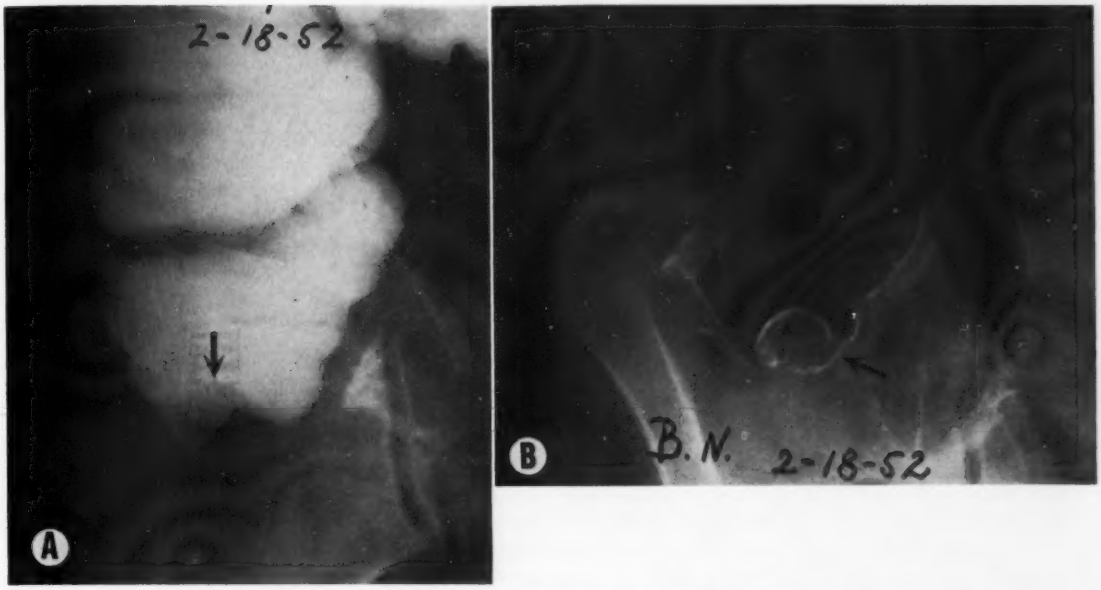

Fig. 1. Case I. (*A*) Shows the intraluminal filling defect at the site of origin of the appendix in the barium filled cecum. (*B*) The barium coated polypoid shadow is seen in the air contrast study.

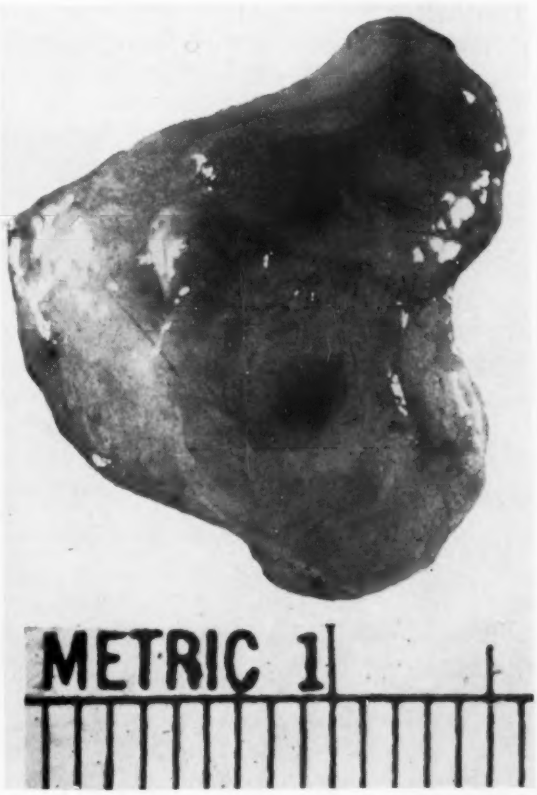

Fig. 2. Case I. A photograph of the granulomatous appendiceal stump removed by cecotomy from this patient.

a granulomatous polypoid lesion was seen in the location of the inverted appendiceal stump. The lesion was excised. Gross pathological examination (Fig. 4) of this lesion showed a 1 cm. nubbin of mucous membrane consisting almost entirely of a protruding nodule arising from a flat base. At the crest were two fused lip-like structures with a central groove. The under surface showed what appeared to be a resected end of an appendiceal lumen.

Comment. Cases I and II demonstrate quite clearly how the stump of the resected appendix inverted into the cecum can give rise to a roentgenographic defect closely simulating a true polypoid adenoma. The third case is somewhat different in that the patient had not had a previous appendectomy.

Case III. M.T., a woman aged thirty-six, gave a history of generalized abdominal pain and diarrhea with tarry stools for four months. Physical examination revealed tenderness deep in the right lower quadrant, and a mass measuring 3 by 6 cm. in the right lower quadrant extending to the midline. Barium study of the colon in July, 1948, showed a spherical defect in the cecum (Fig. 5).

The patient was operated upon on August 7,

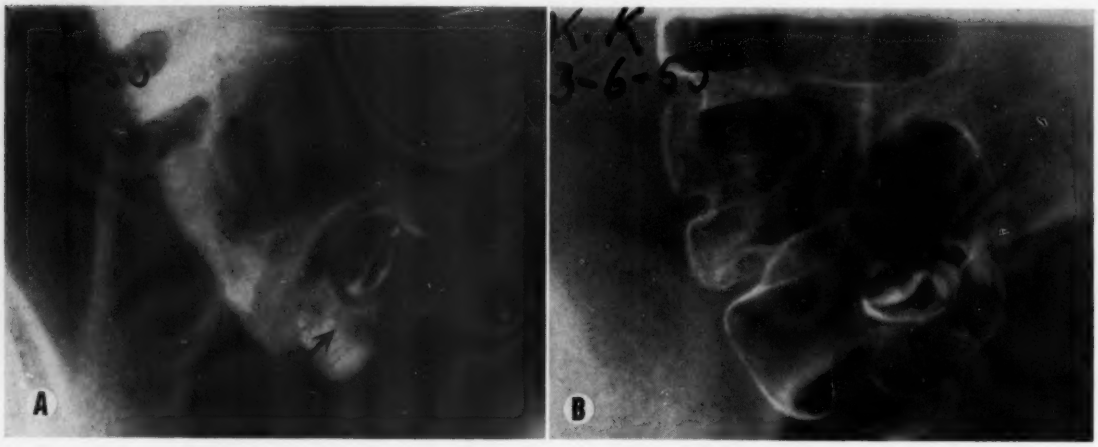

FIG. 3. Case II. (*A*) In the barium filled cecum the granulomatous appendiceal stump presents itself as a filling defect at the site of previous appendectomy (arrow). The rather large, smooth, filling defect above this at the medial aspect of the cecum represents ileocecal valve lips. (*B*) In the pneumocolon study of the polypoid appendiceal stump is beautifully demonstrated. The semilunar crevices retaining barium from the first barium enema study made a week previously were the fused lip-like structures with a central groove described in the gross specimen.

1948. The cecal mass was excised and found to consist of an intussusception of the appendix into the lumen of the cecum. Pathological examination revealed extensive ulceration of the mucosa and acute and chronic inflammation of the wall of the appendix. In addition, at the distal extremity of the intussuscepted appendix there was found a carcinoid.

Comment. This case again illustrates how an invaginated appendix may resemble roentgenographically a polypoid cecal tumor. In this instance the invagination occurred spontaneously or as a result of a carcinoid rather than as a consequence of a surgical maneuver during appendectomy, but the roentgen appearance of the lesions appears to be indistinguishable.

DIAGNOSTIC CONSIDERATIONS

Surgically inverted appendiceal stumps never give rise to symptoms even when overgrowth of granulation tissue takes place unless ulceration of the surface occurs. In this event, bleeding would be expected. The mass is not palpable nor tender. Hence the roentgen finding of a cecal filling defect is usually incidental and unrelated to the symptomatology leading to the examination. In the event of spontaneous intussusception of the appendix into the lumen of the cecum, however, clinical symptoms and signs will manifest themselves.

From the roentgen viewpoint, invaginated appendiceal stumps appear in the

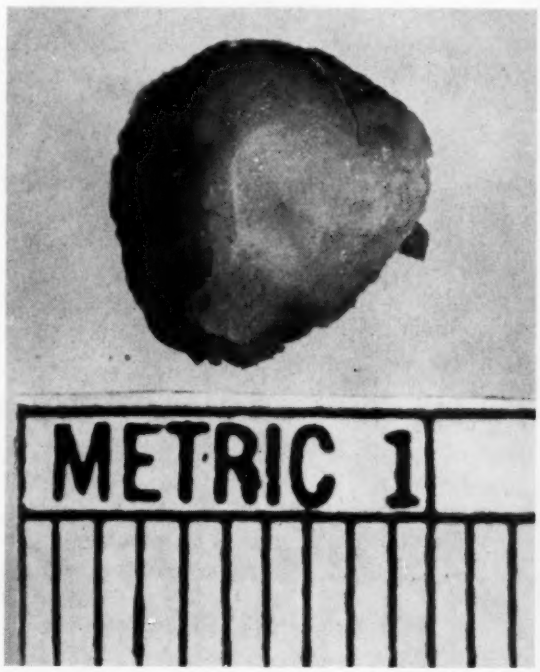

FIG. 4. Case II. Gross specimen of the granulomatous inverted appendiceal stump removed by cecotomy.

barium studies as well circumscribed, rounded filling defects in the cecal wall at the location of the appendix. Such defects are best seen with the aid of compression studies (Fig. 3*A*). They are especially well demonstrated in air-contrast examinations in which they may appear as rounded barium-coated shadows projecting into the lumen of the cecum (Fig. 1*B* and 3*B*). Because their surface may be slightly irregular or lobulated in contour, barium may be retained in the crevices and become visible on the films (Fig. 3, *A* and *B*). It has been suggested[1] that these irregularities may result from the purse-string sutures often used in the surgical procedure.

The close roentgenographic resemblance of these defects to those resulting from adenomatous polyps is obvious. However, in a patient who has undergone appendectomy and who presents a filling defect in the region of the appendiceal stump, one may feel reasonably confident that the roentgen defect represents an inverted stump rather than a true neoplasm. Nevertheless, the possibility of an actual polyp arising in this location cannot be absolutely excluded. Since such polyps may become malignant, operation is indicated even though the roentgenologist strongly favors the diagnosis of inverted appendiceal stump. Furthermore, it is pointed out[7] that other neoplasms such as carcinoma of the appendix, lipomyofibroma and true cecal adenoma may give rise to roentgen defects which are indistinguishable from inverted appendiceal stumps.

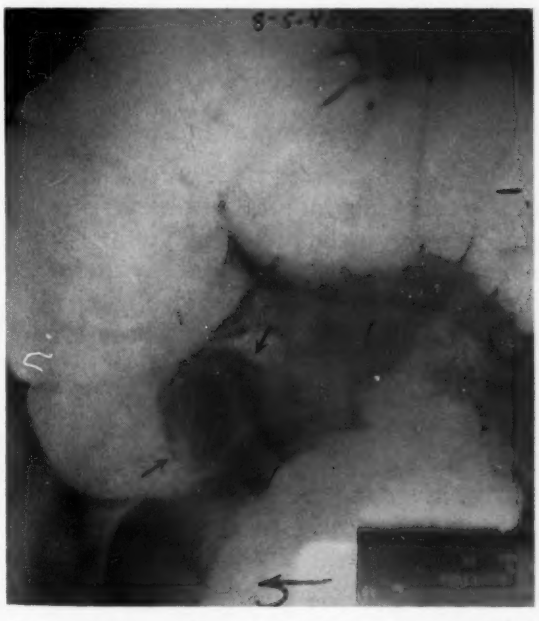

Fig. 5. Case III. The spherical intraluminal defect at the site of origin of the appendix in this case was due to a partially intussuscepted appendix in which there was a carcinoid at its distal portion.

Fig. 6. Case IV. The lower arrow designates a resinous clump of fecal material in the pneumocolon study that may be indistinguishable from a polypoid true lesion. These pseudolesions can often be dislodged with manipulation. They are not constant in repeat roentgen studies. The upper arrow points to ileocecal valve lips.

Among other, more common "lesions" simulating polypoid cecal tumors are (a) resinous fecal clumps and (b) prominent ileocecal valve lips. This close resemblance is demonstrated by the following cases.

Case IV. I.R., a woman, aged fifty-nine, who had undergone endoscopic removal of an adenomatous rectal polyp in June, 1952, again presented herself three months later because of melena. There were no other complaints except for a slight weight loss during the preceding few weeks. There was no history of previous abdominal surgery.

Barium enema examination in September, 1952, showed a filling defect in the tip of the cecum which could not be dislodged (Fig. 6). With the pneumocolon study this defect presented itself as a barium-coated, adherent, positive shadow, and a presumptive diagnosis

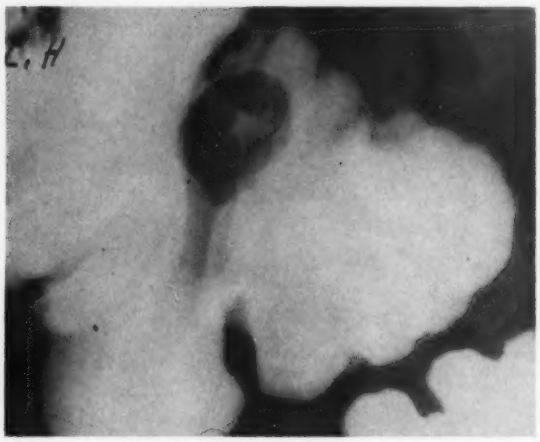

FIG. 7. Case v. Classical ileocecal valve lips. This pseudolesion should never be confused with inverted appendiceal stump lesions because of location. Note the stellate barium in the center of the filling defect. This represents barium within the lumen of the ileum.

of polyp was made. A recheck barium enema pneumocolon study seven days later, however, failed to confirm the findings in the cecum but did show irritability of the cecal tip. Nevertheless exploration of the cecal region was deemed advisable. On September 30, 1952, cecotomy was performed but no abnormality was demonstrated. Appendectomy was done and a diagnosis of obliterative appendicitis was made by the pathologist.

CASE V. C.H., a man, aged forty-eight, was examined by barium enema pneumocolon on numerous occasions over a period of two years because of melena. All examinations revealed normal findings with the same negative shadow portrayed in Figure 7 being present.

This finding was classical for ileocecal valve lips because of its location, permanency, and the presence of barium in the ileum with a smooth rounded defect in the barium-filled cecum.

Adherent fecal clumps are probably the most frequent cause of cecal filling defects. Fortunately, such pseudolesions can usually be avoided by careful preparation of the patient. If, nevertheless, a filling defect due to fecal material is present it may disappear after manipulation, or upon re-examination of the colon, thus excluding the possibility of a true lesion.

The identification of filling defects due to prominent ileocecal valve lips is usually relatively simple because of their location (Fig. 7). If the terminal ileum fills with barium during the examination, the true nature of the defect can be determined with even greater assurance.

In the air contrast study of this part of the colon, this pseudolesion is often well demonstrated and should not be confused with a true lesion (Fig. 6).

Lipomatous tumors of the cecum are generally more radiolucent than other masses arising in this location because of their fat content.

Most extrinsic lesions which could cause defects at the base of the cecum are large enough to displace loops of terminal ileum and are usually palpable or tender[3,8] as, for example, a mucocele of the appendix or granulomas of the ileocecal region secondary to appendicitis (ligneous cecitis). These displace the cecum laterally as well as giving rise to a defect. The mucosal pattern of the cecum is preserved.

Adhesive bands in the cecal region when demonstrable roentgenologically may give rise to pressure defects but show no intraluminal space manifestations except as they indent the cecal outline.

SUMMARY

Surgically inverted appendiceal stumps may roentgenographically simulate polypoid tumors of the cecum by giving rise to filling defects in the cecal wall. If there is a history of appendectomy and if the defect is observed at the site of the base of the appendix, the examiner may feel reasonably certain that the roentgen finding represents an inverted appendiceal stump. Nevertheless, because true polypoid lesions with malignant potentialities may also arise in this location and cannot be absolutely excluded roentgenographically, surgical exploration in such cases is indicated.

The numerous other lesions and pseudolesions which may cause cecal filling defects can usually be differentiated from

inverted appendiceal stumps without difficulty.

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RADIOIODINE RECOVERY IN FECES FOLLOWING AN I^{131} LABELED FAT TEST MEAL*

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PREVIOUS studies[1] made it apparent that radioanalysis of the feces, after ingestion of a radioactive labeled fat meal, could prove valuable as a clinical test for steatorrhea. This study concerns the development and applicability of this procedure in normal and abnormal subjects.

METHODS AND MATERIALS

Twenty-four adults were used as controls. Fourteen were non-hospitalized Duke University students or hospital employees. The remainder were adult hospitalized patients free of any complaints pertaining to the gastrointestinal tract. Fourteen of the controls were prepared for the test with 20 drops of Lugol's solution, three times a day for three days preceding the test. The remaining 10 were given 20 drops of Lugol's solution at the time of the test.†

An I^{131} labeled, barium opacified, fat test meal, as described below,‡ was given each subject. All stools passed during the next forty-eight hours were collected in individual containers.§ Care was taken to keep the samples free of urine. Roentgenographic examination was carried out at forty-eight hours to ascertain that all of the barium sulfate had passed from the gastrointestinal tract before discontinuing sample collections.

A sodium iodide, thallium activated, scintillation crystal detector and a Nuclear Instrument and Chemical Corp., Model 161-A scaler were used in checking all stool samples for radioiodine content. The detector was positioned 15 cm. from the top surface of the sample container. All samples were counted for sufficient time to give statistical accuracy to the data. A 100 gm. homogeneously distributed standard solution containing an amount of I^{131} equivalent to that ingested by the patient—allowing for decay, was counted in the same manner. Direct comparison between the net sample counts per minute and the net standard counts per minute allowed a total radioiodine recovery in the feces to be determined as a percentage of the ingested material.

Twenty-five patients with proven gastrointestinal abnormalities were studied in the same manner as the controls.

RESULTS

The average total radioiodine recovery in the feces was 0.6 per cent of the ingested material, with a standard deviation of 0.4 and a range of 0 to 1.4 per cent. The data are tabulated in Table I.

The results obtained in the abnormal group are shown in Table II. It can be seen that the values are strikingly higher than the normals in most cases.

A comparison of the results of fecal radioiodine recovery with chemical fecal

† It was found that the simultaneous ingestion of the Lugol's solution with the test meal effectively blocked accumulation of the radioiodine by the thyroid. This eliminated the necessity of the three day preparation technique.

‡ A cold emulsion and a "hot" emulsion were prepared for use in the laboratory. The cold emulsion consisted of 200 ml. of peanut oil, 200 ml. of water, and 15 ml. of Tween 80. The "hot" emulsion consisted of 45 ml. of peanut oil, 5 ml. of I^{131} labeled glycerol trioleate (2.0 millicuries of I^{131}), 50 ml. of water, and 4 ml. of Tween 80. Each emulsion was obtained by mixing the ingredients in a Waring Blender for 15 minutes. The I^{131} labeled glycerol trioleate was obtained from Abbott Laboratories under authoriziaton of the United States Atomic Energy Commission.

Each subject was given 1.0 ml. of emulsion per kilogram of body weight. This consisted of cold emulsion plus that volume of the "hot" emulsion which contained 25 microcuries of I^{131}. Ten ml. of barium sulfate were added to the test meal and the entire contents mixed. The subject drank the test meal. The container was rinsed twice with 50 ml. of tepid water which was likewise ingested. The container was assayed for residual radioiodine which was taken into account in the final analysis.

§ The containers used were plastic-lined, ½ pint, waterproof cartons. (Sealright, Alservis containers.)

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Table I

PERCENTAGE RADIOIODINE RECOVERY IN FECES IN NORMALS FOLLOWING AN I^{131} LABELED FAT TEST MEAL

Control No.	Recovery	Control No.	Recovery	Control No.	Recovery
1	.4	9	.7	17	.2
2	1.4	10	.6	18	1.3
3	.6	11	1.2	19	.4
4	.5	12	.3	20	.2
5	.2	13	.5	21	0.0
6	1.0	14	1.0	22	.4
7	.4	15	.4	23	.6
8	.9	16	.5	24	1.3

Average—0.6 per cent.
Standard Deviation—0.4 per cent.

fat recoveries by other investigators is shown in Table III.

DISCUSSION

The radioactive content of the fecal samples was determined without having to open the containers. This eliminated the usual unpleasantness associated with fecal analyses and simplified the method of analysis.

The lack of information concerning the distribution of radioiodine within any given sample required that the effects of distribution, with varying volumes, upon the radioanalysis be determined. Four conditions were studied: 1. A homogeneous distribution. 2. A sample with all radioactivity concentrated in a small cylinder which slants diagonally from top to bottom of the sample. 3. A point source on top of the sample. 4. A point source on the bottom of the sample.

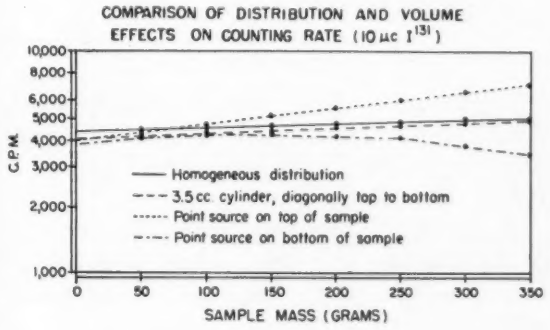

Fig. 1.

Table II

PERCENTAGE RADIOIODINE RECOVERY IN FECES OF ABNORMAL PATIENTS FOLLOWING AN I^{131} LABELED FAT TEST MEAL

Patient No.		Patient No.	
	Vagotomy and gastric resection		Regional ileitis
1	36.6	1	33.4
2	38.4		
3	2.5		Sprue
4	1.2	1	66.5
		2	14.9†
	Vagotomy and gastro-enterostomy		Whipple's disease*
1	21.0	1	60.5
2	20.3		
3	33.0		Cystic fibrosis
		1	59.4
	Chronic pancreatitis*		Functional diarrhea
1	44.0	1	0.1
2	61.0	2	0.4
3	65.0	3	0.2
		4	0.3
	Cancer of pancreas* without major obstruction	5	1.7
		6	1.0
1	0.5		
2	1.9		
	Cancer of pancreas* with major obstruction		
1	29.0		
2	94.0		

* Proven at surgery.
† Remission.

The counting rates obtained from a constant amount of radioiodine with varying sample volumes for all four conditions are shown in Figure 1. These counting rates were normalized with respect to that counting rate obtained from a 100 gm. homogeneously distributed sample. This may be seen in Figure 2. The range of the

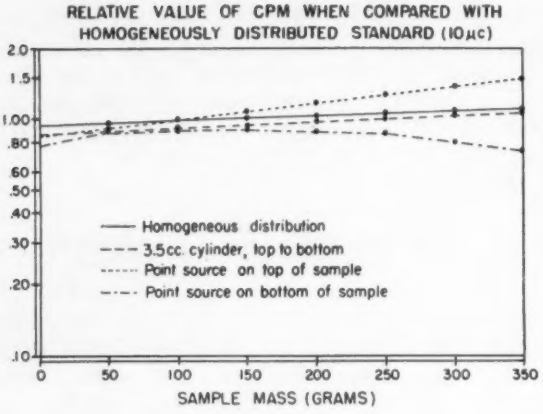

Fig. 2.

error that could be encountered, when comparing the fecal sample with a 100 gm. homogeneously distributed standard solution, may be obtained from Figure 2.

In case of conditions 1 and 2, the maximum error with this comparative technique would be less than 10 per cent for any sample size up to 350 gm. The average mass of the fecal samples obtained in this study was approximately 100 gm., and in Figure 2 it can be seen that the maximum error for this sample size would be less than 6 per cent for any of the four sample distibutions.

The control studies showed a maximum fecal recovery of 1.4 per cent with an average of 0.6 per cent. Because of this low recovery in normals, a 53 per cent error which might be found in condition 3 with a 350 gm. sample, could easily be tolerated. However, the probability of obtaining a point source distribution of radioactivity in any given fecal sample would be extremely low. Even under these extreme conditions, the differentiation between normal and abnormal fecal recovery would be valid due to the low fecal recovery found in normals.

The recovery of radioiodine in the feces in the abnormals may be seen in Table II. Table III lists the results of chemical fecal fat analyses obtained by other investigators in the clinical conditions for which such information was available. The similarity between the results of the fecal fat analyses and the radioiodine recoveries is impressive. The studies of the abnormal will be reported in detail at a later date.

Table III

PERCENTAGE RADIOIODINE RECOVERY IN FECES FOLLOWING AN I^{131} LABELED FAT TEST MEAL COMPARED WITH CHEMICAL FECAL FAT RECOVERY OBTAINED BY OTHER INVESTIGATORS

	Radioiodine Recovery	Chemical Fecal Fat Recovery by Other Investigators
Normal	0 to 1.4	5[2]
Vagotomy and gastroenterostomy	20 to 33	12 to 23[3]
Chronic pancreatitis	44 to 65	9 to 82[2]
Cancer of pancreas with major obstruction	29 to 94	50 to 65[7]
Sprue	66.5	56 to 86[4]
Whipple's disease	60.5	26 to 80[5]
Cystic fibrosis	59.4	50[6]

In all of the studies on the abnormalities listed in Table II, radioiodine blood level determinations of the type described by Baylin and co-workers[1] were carried out. In every instance of high fecal radioiodine recovery there was a corresponding low blood level curve.

The wide differences found between normal and certain abnormal conditions indicate that this procedure may prove to be a valuable clinical test. In view of the similarity of the results of this technique when compared with the chemical fat recovery techniques, it is conceivable that this procedure may serve the same function as a fat balance study.

CONCLUSIONS

1. A comparatively simple procedure for determining fecal radioiodine recovery after ingestion of an I^{131} labeled fat test meal is described.

2. Marked differences in fecal recovery of radioiodine are seen when comparing recoveries in some abnormal conditions with the normal.

3. The results of the fecal radioiodine re-

coveries, as a percentage of an ingested I^{131} labeled fat test meal, are very similar to chemical fecal fat recoveries as reported by other investigators.

4. The technique described may serve as a new clinical laboratory test for steatorrhea.

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EDITORIALS

THE DEBT OF SURGERY TO ROENTGENOLOGY

THE surgeon of today practicing as he does the art and the science of the manual treatment of disease is prone to believe that the art he practices is the orderly evolution of the work of his predecessors for hundreds of years. Without much thought he may assume credit for remarkable results attained by him with the idea that his operative skills should be given the honor. We can give him credit for his dexterity but the honor for his achievements must be divided among many physicians who lived in the past and without whose contributions his skills would be little used. Let us briefly examine our past and see how much we owe to one another and emphasize how recent are our own real achievements.

Medicine, as we know it today, had its origin during the Golden Age of Greece. It was then separated from religion and philosophy, and disease was finally recognized as an abnormality of the elements of the body. Diagnosis was made by taking a history of the ailment and by the use of the senses: observation, palpation, smell and hearing. Medicine was divided into three parts, outward and inward medicine and obstetrics. Outward medicine was astonishingly good; injuries, fractures, dislocations, visible tumors could be observed and rationally treated. Inward medicine was less accurate because it dealt with the unknown solely by inference. To this honest study of disease was added the experimental method by Galen about 200 A.D. Medicine was well on its way with a sound foundation when historical events intervened. The Roman Empire fell, and for the next thousand years the basic Greek concepts of science nearly disappeared in this time known as the Dark Ages. About 1,500 A.D. the Renaissance began. Initiated by many positive events and with dissatisfaction and disagreements with the dogmas of the past, it was based on the new spirit of inquiry. Surgery had disappeared as a respectable part of medicine and medicine itself was based on dialectics, used to prove correct the sterile past.

In the new search for truth within the next three hundred years there were outstanding discoveries and contributions, a few of which I mention since they are regarded as fundamental to the progress of medicine, although at the time of their evolution they did not immediately better the care of the sick.

Anatomy was crystallized by that great Belgian, Andreas Vesalius. This brilliant new knowledge although basic to our progress had no immediate effect upon the practice of medicine or surgery. The last book written by Vesalius was on surgery, but it added nothing to the care of wounds, and anatomy waited nearly four hundred years before its influence became truly fruitful.

A contemporary of Vesalius, the great French surgeon Ambrose Paré, brought to his art an honest, inquiring mind, and the courage to act upon his thinking. His fine character did much to bring respectability to surgery after its loss for a thousand years, but it made little change in practice although many of his innovations were practical and have remained as part of our routine techniques.

William Harvey in 1628 published the new and revolutionary proof of the circulation of the blood. This discovery destroyed the doctrine of the four humors that had dominated medicine for two

thousand years. It was the starting point for physiology but it did not immediately improve the diagnosis and treatment of disease. A study of the literature during the century after his discovery shows no improvement or change in the care of the sick.

Passing rapidly ahead to the eighteenth century we view the influence of John Hunter on practice. He was one of the few surgeons or physicians of his time to apply the experimental method to problems seen in the ward. We need only mention his discovery and recognition of collateral circulation, now so important. But a study of the impact of his work upon the benefit to the patient is disappointing.

By 1800 there were five medical schools in the United States. What was surgery at that time? The records of one of our oldest and probably the first hospital in the United States—The Pennsylvania Hospital in Philadelophia—lists the following operations carried out in that hospital in that year. There were thirteen operations performed, eight for fistula, two for tumors, one for obstruction of urine, one for stone and one for obstructed viscera. Of the patients, two were reported as cured, two were relieved, one taken home by friends (one wonders why, but one can guess), and eight died. Think of it, this was the leading hospital of our country and these operations comprised surgery. Hippocrates did so much better.

Let us pass on to what is surely one of the great discoveries of all times. Crawford Long of Georgia gave ether to abolish the pain of operation 1842, but he did not publish his report until later, so let us examine the surgical service of the Massachusetts General Hospital in 1845, the year before ether was given there. Fifty-six operations were listed and they were carried out on lesions that were demonstrable by diagnostic methods known to the Greeks, lesions that could be seen or felt. Arteries were ligated in two instances, hydrocele tapped four time, fourteen amputations were carried out, cancers of the lip and face were removed nine times, tumors of the breast three times, fistula in ano four times, trephinement was performed twice and miscellaneous operations sixteen times. There was one operation on the viscera, that for a strangulated hernia.

On October 16, 1846, ether was first given to the patient Gilbert Abbott for the removal of a tumor from his jaw. This was successfully carried out, but what was its impact upon the surgical performance in that Hospital? A survey of the operations carried out in the Massachusetts General Hospital in 1848 demonstrates one thing; the number of operations nearly trebled in number—142. One assumes that the operations were painless, but the types of operation were the same. Diagnosis was still the same, still no better than that of the Greeks.

The genius of Pasteur originated bacteriology and the story of its application to surgery by Joseph Lister is well known. This new knowledge finally made operations safer but their scope was little changed because diagnosis was limited by the skills of the eyes and the fingers of the surgeon.

On November 8, 1895, William Conrad Roentgen observed what he called x-rays. He announced his discovery on January 23, 1896 "on a new kind of ray." Within a few days everyone in the world, possessed of a Crookes' tube, had repeated his experiment. Fortunately for medicine he had used living human tissues among the test substances. Had he not done so the use of the roentgen ray in medicine might have lagged for some time. His work crystallized the research of a large company of investigators working in this field for many generations.

Radiopaque objects such as bones and stones received early practical attention. An infinite number of investigators in all countries of the world made studies of the potentialities of the roentgen ray in diagnosis. Walter B. Cannon, while a student in the Harvard Medical School, investigated the movement of food through the

gastrointestinal tract by the use of bismuth as a contrast medium. That method of study was soon applied to the diagnosis of disease. Cancer of the stomach was first shown in 1906, ulcer of the stomach was demonstrated in 1910. A list of operations carried out in Ward E (an operating room for clean cases) of the Massachusetts General Hospital in the five year period 1889–1894, compared to those carried out for the year 1913 is instructive. (I chose 1913 because contrast media were being used, and for sentimental reasons because I was an intern there at that time.)

In the five year period before Roentgen's announcement of his discovery operations were performed for lesions that would have been easily diagnosed by Hippocrates: ovarian tumors, hernias and a few cancers of the colon and stomach that were large enough to be palpable. By contrast in 1913 there were treated by operation large numbers of ulcers of the duodenum and stomach, many cancers of the stomach, colon, and lesions of the gallbladder (demonstrated by roentgenology and contrast media). Something new and vital had entered surgery. Anesthesia and antisepsis and asepsis were necessary fundamental techniques but surgery could not enlarge its scope without the ability to learn more about the pathologic abnormalities of the body before autopsy. Prior to this time we were rendering first aid to lesions that could be seen or felt. Now we had clear cut objectives demonstrated by this startling new discovery.

Surgeons used contrast objects and later solutions to outline the urogenital tract. Dandy in 1919 injected air as a contrast medium into the ventricles to make manifest the anatomic features of the brain and at times to show its abnormalities. Graham and Cole in 1924 developed their test, based upon the ability of the gallbladder to excrete certain chemicals containing iodine. This was a test of function as well as a positive demonstration of gallstones. One could well add to the title of this editioral "the debt of roentgenology to surgery" since clinicians in all fields of surgical specialization have worked in collaboration with roentgenologists for the demonstration of the normal and of the abnormal in all areas of the body.

I have emphasized the all important diagnostic function of roentgenology but probably of equal or more importance in the future is its utility as a research method. It has contributed immeasurably to our knowledge of all facets of body function.

Surgeons have supplemented the completely mechanistic attack on disease by recognizing the presence of, and enlarging the knowledge of, the physiologic and chemical abnormalities of their patients, produced by disease, operation and anesthesia. Methods have been evolved that in part, at least, correct or prevent these variants.

The great advances in surgery in recent years have come from the laboratory to the clinic. The roentgenologist has played an important part in all these advances particularly in neurosurgery, surgery of the heart and great vessels, surgery of metabolic disorders and of the gastrointestinal tract; in fact he has been a fruitful and stimulating companion traveling with us on all roads to solid achievements. From this close and necessary cooperation between us and others there is no limit to our hopes for the future.

I have tried to show how limited was the opportunity for the surgeon until recently, when roentgenology developed to make possible diagnosis of lesions that the surgeon could treat. With surgeons and roentgenologists working together in the new era of the experimental method, there is expectancy that we may reach goals that have until now seemed unattainable.

Frederick A. Coller

PHILIP HOWARD COOK
1878-1954

DR. PHILIP HOWARD COOK, a radiologist of Worcester, Massachusetts since 1905, died at home from a cerebral hemorrhage on March 25, 1954 in his seventy-seventh year. Dr. Cook was born in Portland, Maine in 1878, attended public school in his native city, then was graduated from Harvard College in 1899 and from Harvard Medical School in 1903, both *cum laude*. He was known by his classmates as a quiet, hard-working student, one of the better men in the class.

After an internship at the Worcester City Hospital he took part of the office of a surgeon, Dr. Ernest L. Hunt, and began his practice of roentgenology. The follow-

ing year he was appointed skiagrapher to the City Hospital, a post he held for many years. Later he was on the staffs of the Memorial and Hahnemann Hospitals and was consulting radiologist at Fairlawn, and at Worcester and Grafton State Hospitals.

During both world wars, Dr. Cook was radiologist for the medical advisory boards and held a commission as captain in the Army Medical Reserve Corps. He was active in social, civic and fraternal affairs and during his later years was particularly interested in the Antiquarian Society and the Worcester Medical Library.

Professionally, he was a Diplomate of the American Board of Radiology and a Fellow of the American College of Radiology. He was a member of the Worcester District Medical Society (former secretary and past president), the Massachusetts Medical Society and the American Medical Association, as well as a member and past president of the New England Roentgen Ray Society and a member of the American Roentgen Ray Society since 1915. At the time of his death he was librarian at the Worcester Medical Library, of which he was one of the initiators and incorporators, and Chairman of the Board of Trustees of of the Library. After his retirement from active practice in 1946 he spent many hours reviewing, re-arranging and cataloguing the books and pamphlets of the library. He also helped to revive the medical museum and to assist in editing the *Worcester Medical News*. He was of equal value to the Antiquarian Society and helped both organizations by generous gifts from his estate.

Dr. Cook was a bachelor all of his life, and was a frugal man in spirit as well as body. His chief hobby was old sailing ships, and he had a considerable fund of knowledge concerning the old days of the clipper ships and the windjammers. He indulged in a few maritime trips which he enjoyed tremendously, but most of his life he was, in his own words, "a piazza sailor" partaking of adventure vicariously through books and journals, of which he had a goodly collection.

His frugality led to wise investment of his savings, and at his death he provided generous bequests for his favorite local institutions, the medical library, the Boys Club and the Antiquarian Society. After other specific bequests to organizations and individuals, he bequeathed the remainder of his estate to Harvard College.

His will specified that his estate be used "to establish the Philip H. Cook Fund for Radiology," the income therefrom to be "used for teaching and research in radiology at Harvard Medical School." He expressed the hope that the resources he was giving to Harvard would be sufficient to endow a Chair of Radiology, the income to be available either for the salary of the incumbent professor or for the support of his work. The approximate current value of Dr. Cook's bequest is $425,000. Thus, after half a century, radiology is coming of age as judged by the meaning of this new endowment. Future radiologists and their patients will owe their gratitude to such a pioneer in the specialty and to such a generous donor as Philip Howard Cook, M.D.

Merrill C. Sosman, M.D.

AUBREY O. HAMPTON
1900-1955

ON July 17, 1955, Dr. Aubrey O. Hampton died after a prolonged illness at the age of fifty-four. With his death, American radiology lost one of its most independent and brilliant thinkers.

Dr. Hampton was born in Copeville, Texas. He obtained his early education in that State, graduating from Baylor University Medical School in 1925. Soon after graduation, he started his radiological training at the Massachusetts General Hospital in Boston. His most fruitful years were while he was associated with this hospital and the Harvard Medical School. On retirement of Dr. George W. Holmes, Dr. Hampton was appointed Chief of the

Department of Radiology at the Massachusetts General Hospital. He served in that capacity until he entered the army to become Chief of the Department of Radiology at the Walter Reed Army Hospital, Washington, D. C., where he stayed for the duration of the war.

After the war, Dr. Hampton joined the group of Drs. Groover, Christie, and Merritt and headed the Department of Radiology at Garfield Hospital in Washington, D. C. His connection with the army was continued as radiological consultant to Walter Reed Hospital. During the reorganization of the Medical Department of the Veterans Administration, he was appointed Chief Consultant in Radiology to the Medical Director of the Veterans Administration. In this position he greatly influenced the construction, equipping, and staffing of roentgen departments of the Veterans Administration Hospitals throughout the country. Under his guidance, new specifications were worked out for the radiological equipment in the Veterans Administration; they greatly affected the way in which the roentgen equipment was built by the various manufacturers after the war and established a trend which is still felt.

Other organizations made use of the unusual abilities of Dr. Hampton and his presence in the Nation's Capitol. He was Consultant to the Clinics of the National Institutes of Health, and Representative of the American Roentgen Ray Society at the National Research Council. He was chiefly responsible for the creation and maintenance of a Fellowship for Radiological Pathology at the Armed Forces Institute of Pathology. His great interest in the fellowship was recognized by the American Roentgen Ray Society which, after his death, named it the "Aubrey O. Hampton Fellowship of Radiological Pathology."

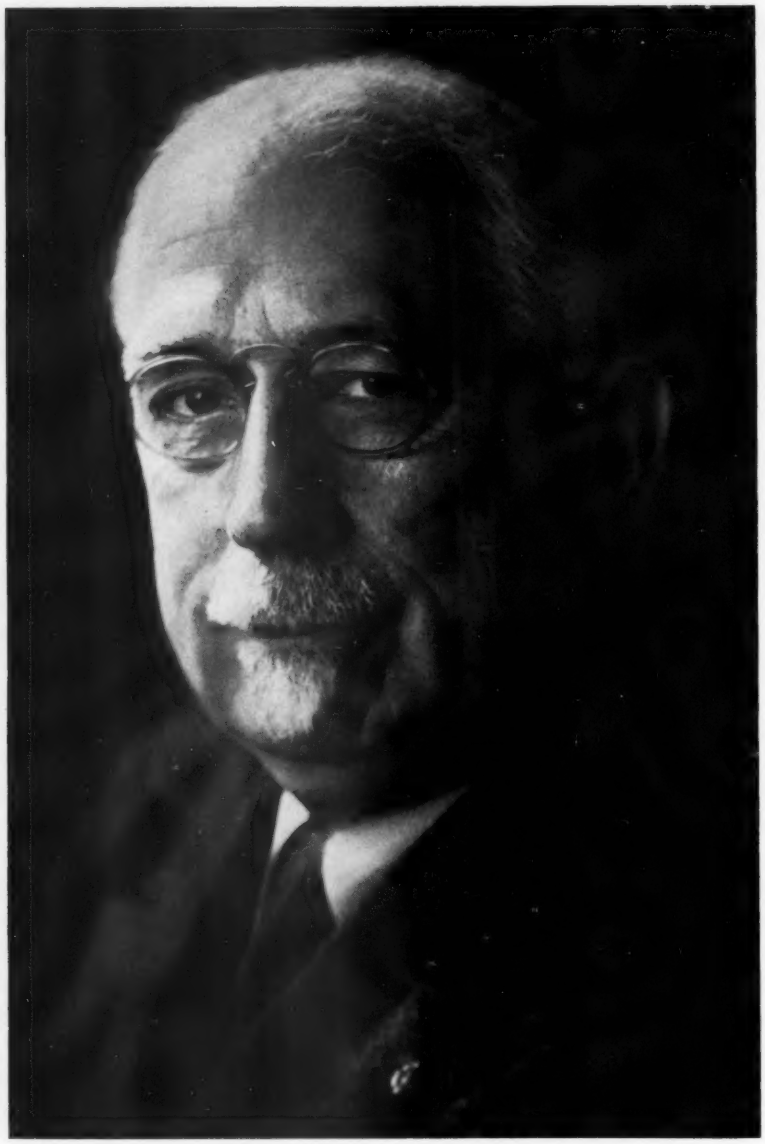
Dr. Hampton's outstanding papers were on the radiological aspects of pulmonary pathology—disease of the middle lobe, pulmonary infarction, lipoid pneumonia, the radiology of the intervertebral discs, and a short but significant paper on the diagnosis of bleeding duodenal ulcers. Most of his papers offered original ideas and became classics.

Although systematic, didactic teaching was something which Dr. Hampton abhorred; he was an unusually stimulating instructor. Often skipping the preliminary reasons for making a diagnosis, his accuracy was such that it was a challenge to his pupils to find out why he made his decision, and to discover his way of thinking.

Dr. Hampton was probably at his very best as a clinical radiologist in the daily routine. He was interested in his patients, and radiology was only a part of the picture. His unerring ability to see the important aspect of a clinical problem was refreshing and exciting even for those who had been with him for years. No wonder that he had innumerable ardent clinical friends who made him the center of their investigating teams. His completely independent approach to every case, which relied so much on what he could discover with his own five senses, was constantly stimulating. He set a great example to his students to think independently rather than to depend entirely on text book wisdom.

"Hamp" was a man of unusual charm who made friends very easily and kept them. Illness made the last years of his life difficult. Whenever he was well, his charm and resourcefulness were as great as ever. Although his early death may have come as a relief to him, it was a great loss to his wife, his two children, and to his many friends.

Richard Schatzki, M.D., and
James R. Lingley, M.D.



CHARLES W. PERKINS
1878-1954

IN THE death of Dr. Charles W. Perkins the medical world loses one if its distinguished members and the city and state in which he lived loses one of their most highly respected members of the medical profession as well as one of its outstanding citizens. Dr. Charles Winfield Perkins, 76 years of age, radiologist and a member of the Norwalk, Connecticut, Hospital staff, died in Baker Memorial Hospital in Boston, Massachusetts, after a long illness. He was a member of one of Connecticut's outstanding families. He practiced in Norwalk, Connecticut, for 24 years and was chairman of the Norwalk Cancer Society from 1951 to 1953. Prior to that, he had been

active in cancer prevention work for many years, being active in the Fairfield County cancer organization and a charter member of the Norwalk Tuberculosis and Heart Association.

Dr. Perkins was born in Chester, Pennsylvania. He was graduated in 1901 from Hahnemann Medical College and Hospital, Philadelphia, and served as an interne at Metropolitan Hospital until 1903. He began his practice in Trenton, New Jersey, and was assistant surgeon there at McKinley Hospital. In 1913–14 he did post-graduate work in Paris, Berlin and London. The following year he became instructor at Post-Graduate College, New York, and Professor of Roentgenology at New York Ophthalmic College and Hospital. He served in the Army Medical Corps overseas during World War I and was made a major in the Medical Reserve Corps.

In both the medical world and in lay organizations, Dr. Perkins occupied numerous positions of leadership. He was a Fellow of the New York Academy of Medicine and member of the American Legion. He also was the author of numerous articles on medicine, surgery and radiology.

Beyond his activity in the medical world, Dr. Perkins' interests extended to other fields. Some indication of "the man behind the doctor" may be gathered from the fact that he was an authority on birds, trees, flowers and other nature lore. As might be imagined, he was a great camera enthusiast. He had made two trips to Mexico and Yucatan and in those areas, as well as elsewhere, he made numerous films which he enjoyed showing to both scientific and lay organizations. Dr. Perkins was in great demand as a speaker before civic and church clubs and other organizations.

The death of such a distinguished individual leaves a void that is not easily filled. Dr. Perkins met death with the same fine attitude of mind with which he faced life.

L. R.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS*

ASSOCIATION OF UNIVERSITY RADIOLOGISTS

The Association of University Radiologists is a new society that was formed two years ago at a meeting at Washington University, St. Louis. This organization was formed in recognition of the fact that radiologists in university hospitals have peculiar needs that are not adequately served by the present national societies. The purposes of the Society are: (A) The encouragement of laboratory and clinical investigation in radiology by the informal exchange of ideas; (B) The stimulation of interest in academic radiology as a medical career; and (C) The advancement of radiology as a medical science. Membership is limited to those holding full-time faculty positions in university departments of radiology. At present, there are 70 members representing 29 medical schools throughout the country.

The next annual meeting will be held at the University of Rochester in May, 1956, the exact date not yet having been determined. All correspondence and queries should be directed to the Secretary-Treasurer, Dr. Robert J. Bloor, 260 Crittenden Boulevard, Rochester 20, New York.

GOLD MEDAL AWARDS TO DRS. PENDERGRASS AND DONALDSON

The Gold Medal of the American College of Radiology will be awarded to Dr. Eugene P. Pendergrass of Philadelphia and Dr. Samuel W. Donaldson of Ann Arbor in recognition of outstanding contributions during their careers in the science of Radiology.

In the thirty year history of the American College of Radiology, Gold Medals have been presented to only thirteen other persons, including the distinguished French scientist, Madame Marie Curie, discoverer of radium, and Dr. W. D. Coolidge, General Electric Company, inventor of the modern roentgen-ray tube.

The Gold Medals will be presented to Drs. Pendergrass and Donaldson at ceremonies during the Annual Meeting of the College on February 10, 1956, in Chicago.

COURSE IN MEDICAL USES OF RADIOACTIVE ISOTOPES

A four months' course in the medical uses of radioactive isotopes will be given at the Queens General Hospital in cooperation with the Atomic Energy Commission. This course will commence on Tuesday, February 14, 1956, and will consist of weekly four hour sessions covering lectures, laboratory exercises, and clinical management of patients.

Enrollment will be limited to fifteen.

Information and application forms may be obtained from Dr. L. B. Goldman, Director, Radiation Therapy Department, Queens General Hospital, 82–68—164th Street, Jamaica 32, New York.

PUBLICATIONS FROM 7TH INTERNATIONAL CONGRESS OF RADIOLOGY

Two publications from the 7th International Congress of Radiology of interest to radiologists have recently appeared. The first of these, "the Reports Submitted to the International Commission on Radiological Units," appeared as Supplement 117 of Acta Radiologica. The second contains the recommendations of the International Commission on Radiological Protection, published as Supplement 6 of the British Journal of Radiology. Copies of these may be obtained by writing to the respective journals.

* The list of Meetings of Radiological Societies appears in the January, 1956, issue of the Journal, and will be published in the March number.

M. D. ANDERSON HOSPITAL CANCER SYMPOSIUM

The University of Texas M. D. Anderson Hospital and Tumor Institute (Texas Medical Center, Houston 25, Texas) will give its Tenth Annual Symposium on Fundamental Cancer Research on March 29, 30, and 31, 1956. The opening session of the program will consist of an open house for all symposium members of the various research programs which are in progress at M. D. Anderson Hospital. Dr. Grant Taylor, Dean of The University of Texas Postgraduate School of Medicine and head of the department of pediatrics at M.D. Anderson Hospital is general chairman of the Symposium.

ATOMIC ENERGY COMMISSION FELLOWSHIPS

The Atomic Energy Commission has made available a number of special fellowships for the academic year 1956–57 in two relatively new fields of seientific endeavor closely related to the atomic energy program—industrial hygiene and radiological physics.

The radiological physics program provides for an academic year of formal courses at one of three universities to which fellows may be assigned, followed by transfer to a corresponding cooperating AEC installation, where the fellows train for approximately three months in applied health physics. The three centers of the program are at the University of Rochester, in cooperation with Brookhaven National Laboratory; the University of Washington, in cooperation with the Hanford Works; and Vanderbilt University, in cooperation with Oak Ridge National Laboratory. The programs at all three centers will include training in modern physics, radiation biology, radiation instrumentation, industrial hygiene and toxicology, biology, and research. As many as 25 fellows may be appointed in each of the three programs.

Industrial hygiene fellows attend either Harvard University or the University of Pittsburgh. Course work varies with the university selected and with the interests and undergraduate preparation of the individual. All fellows are required to take course work in public health and biostatistics; electives may include engineering, health physics, toxicology, industrial medicine, and related subjects.

Basic stipend for AEC fellows is $1,600, with an additional $350 allowed for spouse and $350 for each dependent child. Fellowship awards include payment of normal tuition and fees required by the university, and a travel allowance of six cents per mile for the fellow (not dependents) from the place of application to his assigned university. Radiological physics fellows receive an allowance for travel between the university and the cooperating laboratory. Industrial hygiene fellows are assisted financially to attend the annual meeting of the American Industrial Hygiene Association. One or more years of graduate work or industrial experience may qualify an industrial hygiene fellow for an additional $200 in the basic stipend.

AEC fellowship applicants may designate their choice of institutions and, when possible, assignments will be made accordingly, although the Oak Ridge Institute of Nuclear Studies cannot guarantee compliance with the choice. Requirements for AEC fellows include a bachelor's degree in physics, chemistry, or engineering, acceptability for graduate work at the university to which the fellow is assigned, and United States citizenship; applicants must be under 35 years of age. Radiological physics fellows should have minors in mathematics, biophysics, or similar fields (although applicants with other qualifications may be considered in speical circumstances).

Additional information and application blanks may be obtained from the Fellowship Office, University Relations Division, Oak Ridge Institute of Nuclear Studies, P.O. Box 117, Oak Ridge, Tennessee. Completed applications, supporting letters of reference, and transcripts must reach the Institute not later than March 1, 1956, to ensure consideration. Appointments will be made on or about March 15, 1956.

ABSTRACTS OF RADIOLOGICAL LITERATURE

Department Editor: T. Leucutia, M.D., Harper Hospital, Detroit 1, Michigan

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ROENTGEN DIAGNOSIS

Head

Hope, John W., Spitz, Eugene B., and Slade, Harry W. The early recognition of premature cranial synostosis. *Radiology*, Aug., 1955, *65*, 183–193. (From: Departments of Radiology and Neurosurgery, The Children's Hospital of Philadelphia, Philadelphia, Penna.)

The characteristic roentgen findings in fully developed craniostenosis are known to most radiologists, but in these late cases irreparable damage has been done to the brain. Early recognition of this disease before the damage has occurred is most desirable.

Early clinical features important in the diagnosis of craniostenosis are an abnormally shaped head, a palpable ridge over the closed suture with no movement of the adjacent skull bones, and frequently exophthalmos. The most important early roentgen finding is the presence of extremely narrow sutures with increased density of the bone margins. Roentgenograms reveal an abnormal contour of the skull even before closure occurs. After a suture closes compensatory expansion along free suture lines becomes inadequate and the progressively increasing intracranial pressure causes thinning of the inner table of the vault with a great increase of convolutional markings. Exophthalmos results from depression of the orbital plates.

Treatment consists of preventive surgery with removal of a strip of bone adjacent to the prematurely closed suture. Strips of polyethylene sewed over the raw bone edge retard formation of new bone. Operation should be performed before six months and preferably at about three months of age, because of the rapid growth of the brain during the first year of life. Early diagnosis and operation will almost always prevent the serious sequelae, such as visual and auditory difficulties, mental impairment, convulsive seizures, and bizarre appearance. Cerebral dysgenesis offers the most difficulty in differential diagnosis.

Four cases of premature cranial synostosis and one case of microcephaly secondary to cerebral dysgenesis are presented.—*Harold C. Hamilton, M.D.*

Begg, A. C., and Robinson, R. G. Radiological calcification in posterior fossa tumours. *Brit. J. Radiol.*, Sept., 1955, *28*, 470–472. (From: Departments of Diagnostic Radiology and Neurosurgery, Dunedin Hospital and University of Otago Medical School, Dunedin, New Zealand.)

The incidence of calcification in infratentorial lesions has been discussed in the literature. Some authors contend that it is uncommon, while others say that it is almost as common as in tumors above the tentorium.

A series of 82 cases of verified posterior fossa tumors was studied.

The conclusion is drawn that calcification may be detected roentgenologically in about 10 per cent of posterior fossa tumors which is about similar to that found in tumors above the tentorium.

It is pointed out that a special view of the skull is necessary and the authors describe this projection as the half-axial view. Their experience agrees with that of others, that calcification in infratentorial tumors is likely to be found in astrocytomas, ependymomas, and in meningiomas.—*Richard E. Kinzer, M.D.*

Sherman, Robert S., and Caumartin, Hugh. The roentgen appearance of adamantinoma of the mandible. *Radiology*, Sept., 1955, *65*, 361–367. (From: Department of Diagnostic Roentgenology, Memorial Center for Cancer and Allied Diseases, New York, N. Y.)

Thirty adamantinomas, histologically confirmed, were studied by the authors in an attempt to establish roentgen criteria for diagnosis. Twenty-four of these were classed as typical; six were considered atypical on the basis of roentgen appearance. Thirty-three additional cases diagnosed as adamantinoma of the maxilla or mandible were not suitable for this study.

Adamantinoma is a slow-growing tumor which is relatively asymptomatic in its early stages. It is a progressive, invasive and destructive lesion of low grade malignancy. Complete removal is curative. Metastasis occurs occasionally in the cervical lymph nodes, rarely in the lungs.

Most adamantinomas present a characteristic roentgen picture permitting a dependable diagnosis by the roentgenologist. The site of origin appeared to be in the medullary portion of the mandible in every instance. There was a definite tendency toward early extension beyond the jaw bone, the tumor breaking through the cortex, with the formation of a soft tissue mass. The most characteristic roentgenographic feature of adamantinoma was the presence of loculations. The tumors showed a loculated, more or less oval, configuration. The effect upon the cortex of the mandible was threefold; expansion, destruction and a form of productive change characterized by scalloping. In no case was there evidence of periosteal reaction or pathologic fracture. The borders of the adamantinoma were distinct in all cases. The tumors averaged about 5 cm. in diameter with a range from 2 to 18 cm.

Fibrous dysplasia, giant cell tumor, follicular cyst, hemangioma and septate forms of cancer metastases must be considered in differential diagnosis.—*A. W. Sommer, M.D.*

McCLURE, RICHARD F. Laminagraphy in acute maxillofacial injuries. *Radiology*, Sept., 1955, *65*, 408–411. (Address: 1921 South Catalina Avenue, Redondo Beach, Calif.)

Roentgenographic examination of the maxilla and mandible for evidence of fracture is a difficult and sometimes unsatisfactory procedure in the severely injured patient. Because of this and the resultant delay in instituting proper treatment by the oral surgeon, the author began using laminagraphy as the initial procedure in injuries of the face and jaw.

The advantages of this method are: (a) Positioning of the head is simple—in most cases a single position will suffice. (b) Repeat laminagrams are usually not necessary because of unsatisfactory position of the part, while with the routine methods repetition is often required. (c) More information is gained, as on several occasions fractures were found on the laminagrams that had been missed on the routine films or at best has been difficult to see. (d) The ease and accuracy of laminagraphy saves time for the patient and the examiner. The one real weak point in this technique is the lack of clear visualization of the malar arch. While the total radiation to the patient is 16.3 r as compared to 11.5 r with the routine method, it is felt that this difference is of little significance in view of the other advantages of laminagraphy.

The technique of obtaining these laminagrams is described and 8 laminagrams are reproduced showing fractures of the maxilla and mandible.—*Donald N. Dysart, M.D.*

NECK AND CHEST

EPSTEIN, HAROLD C., and LOEB, WILLIAM J. Thymic tumor of the pharynx. *J. Pediat.*, July, 1955, *47*, 105–108. (From: Department of Pediatrics, Western Reserve School of Medicine and Department of Otolaryngology and Pediatrics, Mt. Sinai Hospital of Cleveland, Cleveland, Ohio.)

The authors report a pedunculated thymic tumor in the hypopharynx of a three week old infant. The mother noted the appearance of a mass protruding from the mouth when the baby regurgitated and that it disappeared when the baby swallowed.

Physical examination revealed the presence of a mass in the mouth and pharynx. The barium swallow demonstrated the mass within the lumen of the cervical and upper thoracic portions of the esophagus. Direct laryngoscopy revealed the base of the pedunculated mass to be in the left hypopharynx, in the medial portion of the pyriform sinus. The mass was removed with a nasal snare.

The microscopic sections of the tumor showed a polypoid structure consisting of isolated groups of thymic tissue containing Hassall's corpuscles. Each lobule of thymic tissue was widely separated by fibroadipose tissue. A diagnosis of hamartoma of the pharynx was made.

A probable embrylogic origin from the fourth visceral cleft is presented.—*James F. Martin, M.D.*

ST. JOHN, ELMER G., and WOO, ZUNG-PAH. Rhabdomyosarcoma of the nasopharynx. *Radiology*, Aug., 1955, *65*, 218–222. (From: Departments of Radiology and Pathology, Binghamton City Hospital, Binghamton, N. Y.)

Rhabdomyosarcoma of the nasal cavity is a rare tumor. It often begins as a polypoid growth and may be mistaken for nasal polyps. Occurrence is chiefly in childhood or adolescence. Metastasis is usually by way of the lymphatics at first, but terminally widespread dissemination by the blood stream may occur.

A case report is presented of a 4-year-old boy on whom this diagnosis was made. Following surgical removal of large pearl-gray polypoid masses from the nasopharynx, deep roentgen therapy using a 200 kv. apparatus with a half-value layer of 2.3 mm. Cu was given. Five 4 by 5 cm. field were irradiated, giving 200 r (air) to each of 2 ports per day for an estimated mid-nasopharyngeal tumor dose of 6,116 r in about 8 weeks. A good temporary response was obtained, but the tumor recurred and the patient died about 2 months after roentgen therapy and about 6 months after onset of symptoms.

These tumors in general are considered malignant and are usually radioresistant.—*Donald N. Dysart, M.D.*

OVERHOLT, RICHARD H., and NEPTUNE, WILFORD B. (Boston, Mass.) The significance of the anterior segment in bronchiectasis. *J. Thoracic Surg.*, Sept., 1955, *90*, 288–299.

The authors stress unrecognized bronchiectasis in the anterior segment of the upper lobes as a possible factor in the failure of surgical treatment of bronchiectasis.

Two cases are presented to illustrate the consequences of initial oversight, usually incomplete bronchography requiring reoperation. Clockwise rotation of the anterior segment following resection of the middle lobe, lingula or basal segments brings the anterior segment into a dependent position. Minimal, pre-existing bronchial abnormality is then likely to become a process of pathological significance. While isolated anterior segmental bronchiectasis is rare, about 8 per cent of the authors' cases with bronchiectasis in whom surgery is required for treatment have involvement of the anterior segments. It is most commonly found in association with bronchiectasis of the middle lobe and lingula.

The technique for the removal of the anterior

segment alone or together with the middle lobe or lingula is presented.—*Paul C. Olfelt, M.D.*

Miller, Frank L., and Walker, Rhey. The roentgen characteristics of pulmonary paragonimiasis. *Radiology*, Aug., 1955, *65*, 231–235. (Address: Walter Reed Army Hospital, Washington 10, D. C.)

Chest roentgenograms of 227 Korean prisoners of war whose sputum smears were positive for the ova of Paragonimus westermani were studied to ascertain whether or not characteristic roentgen findings are present in pulmonary paragonimiasis.

It was found that cyst formation occurred with sufficient specificity and frequency to suggest that it was a characteristic finding. The typical cystic lesion of paragonimiasis was 1 to 2 cm. in diameter, ovoid, and surrounded by a narrow ring of fibrosis with varying degrees of pericystic inflammatory reaction, although considerable variation in size and shape of the cyst occurred. A characteristic cystic lesion was observed in 63 per cent of the patients in the series, while 14.5 per cent had normal chest roentgenograms.

The lesions were almost always peripherally located, and all portions of the lung in a vertical plane were equally involved. Calcification was not a component of a characteristic lesion.—*Harold C. Hamilton, M.D.*

Keats, Theodore E. Generalized pulmonary emphysema as an isolated manifestation of early cystic fibrosis of the pancreas. *Radiology*, Aug., 1955, *65*, 223–226. (From: Department of Radiology, University of California School of Medicine, San Francisco, Calif.)

The recognition of generalized pulmonary emphysema as an isolated manifestation of the earliest phase of pulmonary involvement in cystic fibrosis of the pancreas is of great importance if treatment is to be instituted prior to the development of irreversible lung changes.

Roentgenographically, the early changes are not always easily recognized in children. Films of good technical quality taken in anteroposterior and lateral projections are necessary. Increase in the anteroposterior diameter of the chest, increased width of the retrosternal and retrocardiac spaces, elevation of the ends of the ribs, flattening of the domes of the diaphragm, increased radiability of the lungs with paucity of parenchymal markings, and diminished size of the cardial silhouette are manifestations most often observed. Films exposed in inspiration and expiration may demonstrate poor air exchange.

Three cases illustrated and discussed by the author suggest that generalized pulmonary emphysema may be a transient stage which has its onset in the newborn, and soon develops into a stage of superimposed atelectasis and infection. While generalized emphysema predominates, the differential diagnosis is not usually a problem if the possibility of cystic fibrosis of the pancreas is kept in mind. Conditions which might simulate this condition include tracheal or bilateral main stem bronchial obstruction, congenital pneumatoceles, bronchiolitis, and hyalin disease of the newborn.—*A. Ralph Watson, M.D.*

Semple, Thomas, and McCluskie, R. A. Generalized hypertrophic osteoarthropathy in association with bronchial carcinoma; a review, based on 24 cases. *Brit. M. J.*, March 26, 1955, *1*, 754–759. (From: Victoria Infirmary, Glasgow, and Hairmyres Hospital, Lanarkshire, Scotland.)

Twenty-four examples of generalized hypertrophic osteoarthropathy in association with bronchial carcinoma have been collected. In 16 of the patients, joint disability was the first evidence of disease and in many this preceded the detection of the pulmonary malignancy by many months. In several of the patients the "rheumatic" affliction was sufficient to confine them to bed and was completely crippling.

Roentgenologically these patients demonstrated an irregular, but symmetrical osteoid sheathing of the long bones. The lower ends of the forearm and leg bones, metacarpals and metatarsals were most frequently affected. There were extra-articular thickening and nonspecific degenerative changes in the articular cartilages. In advanced cases deformities and even subluxation occurred.

Finger clubbing was almost invariably associated with osteoarthropathy but was also observed in certain types of chronic lung disease without periosteal reaction or joint involvement.

The relief of symptoms after resection of the carcinoma was dramatic and almost immediate. In a few months the roentgen evidence of the disease disappeared.

In the authors' series, the tumors were mostly bulky, circumscribed peripheral neoplasms with central necrosis present in all specimens.

An interesting discussion of the etiology of osteoarthropathy is appended. It is generally accepted that increased peripheral blood flow produces the pathological changes but the mechanism for producing this increased flow is poorly understood. Several theories are presented.

The authors believe that bronchial carcinoma is the chief cause of generalized hypertrophic pulmonary osteoarthropathy and emphasize that these changes may precede the roentgenological appearance of the lung tumor.—*Lawrence A. Davis, M.D.*

FINBY, NATHANIEL, and STEINBERG, ISRAEL. Roentgen aspects of pleural mesothelioma. *Radiology*, Aug., 1955, *65*, 169–182. (From: Departments of Radiology and Medicine, The New York Hospital-Cornell Medical Center, New York, N. Y.)

Mesothelioma of the pleura is a neoplastic disease which develops from the lining cells of the pleura. Two groups of mesothelioma have been recognized, the localized and the diffuse.

Localized pleural mesothelioma is usually a benign disease, but may prove to be the early stage of the diffuse malignant type. Roentgenographically, it is manifest as a circumscribed lobulated mass in the plane of the pleura which cannot be differentiated from other intrathoracic tumors. Pleural effusion is uncommon, or a late manifestation. The diagnosis can be made only after thoracotomy and microscopic study of the tumor. Prompt surgical removal of the tumor may be curative.

Diffuse pleural mesothelioma is always a malignant disease. Roentgenographically it often appears initially as a massive pleural effusion. Pneumothorax, after removal of the fluid, permits visualization of the nodular pleural densities. Pleural thickening and rapid recurrence of the pleural exudate, associated with fixation of the mediastinum, are characteristic roentgen findings. The prognosis is poor. Diffuse pleural mesothelioma is radioresistant, and radiation therapy is palliative. Radioactive isotopes (I^{131} and Au^{198}) have been used intrapleurally to decrease the formation of fluid.

The authors present five cases of localized pleural mesothelioma, and seven cases with the diffuse form.—*A. W. Sommer, M.D.*

STARKEY, GEORGE W. B. (Boston, Mass.) Spontaneous rupture of the esophagus; with presentation of four new cases. *J. Thoracic Surg.*, Sept., 1955, *30*, 300–315.

The author reviews the problem of "spontaneous" rupture of the esophagus and presents four new cases.

Clinically, spontaneous rupture of the esophagus is characterized by the acute onset of severe chest pain which may radiate to the upper abdomen and shoulders and which may be aggravated by breathing. There is often an antecedent nausea and vomiting. Cervical subcutaneous emphysema may be evident.

Chest roentgenograms may show mediastinal and subcutaneous emphysema, and if the perforation extends out into the pleural space, pneumothorax, tension pneumothorax or hydro-pneumothorax may be evident. A swallow of 10–20 cc. of lipiodol preceding the roentgen examination almost invariably demonstrates the esophageal leak which ordinarily is in the terminal esophagus. As is usual in these cases, the esophagi in the four reported cases were normal except for the rupture. The mechanism of the rupture is not clear.

A brief discussion of treatment is included.—*Paul C. Olfelt, M.D.*

HAJDU, N. H., and SIDHVA, J. N. Parasternal diaphragmatic hernia through the foramen of Morgagni; with report of a case. *Brit. J. Radiol.*, July, 1955, *28*, 355–357. (From: St. George's Hospital, London, S. W. 1, England.)

Diaphragmatic hernia through the foramen of Morgagni is one of the least common of the types of diaphragmatic hernia. Apparently the defect is congenital but the hernia is generally not developed until later in life. The symptoms and signs are not diagnostic for a particular type of hernia unless a succussion sound coinciding with the heart beat is heard—and this sign is thought pathognomonic.

Roentgenologically, a hernia through the foramen of Morgagni usually appears as an opacity in the right or left costophrenic angle and if gas filled intestinal loops are present in the thorax the diagnosis is obvious. When gas is not present, barium enema study should settle the diagnosis. However, according to the authors, when only omentum is present in the hernial sac they have found two useful roentgenological signs. These signs they feel are more helpful than pneumoperitoneum, which in itself is a difficult procedure, and if the hernial opening has dense adhesions the sac may not be demonstrable. They have noted that the transverse colon on the plain film shows an inverted U or V shape. This can be better shown by filling the colon with barium and standing the patient upright; and as the patient breathes in, the inverted V widens, and as he breathes out, the inverted V narrows, causing an appearance of a bird flapping its wings. They have therefore named these two findings the inverted V or U sign, and the flapping wing sign.—*E. C. Davis, M.D.*

ABDOMEN

KATZ, ISADORE. A radiolucent pneumatic compressor for mucosal studies. *Radiology*, Aug., 1955, *65*, 271–275. (From: Department of Radiology, Veterans Administration Hospital, Brooklyn 9, N. Y.)

A simple, inexpensive pneumatic compressor for mucosal studies of the gastrointestinal tract is described. Detailed instructions are given for the construction of the device, which consists of an ordinary inflatable rubber compression bladder mounted in a radiolucent triple-layered Masonite board. With the device in place on the roentgenographic table for horizontal fluoroscopy, the rubber bladder is inflated to produce the desired degree of

compression. It has been found especially effective in compression study of the gastroenterostomy area following subtotal resection of the stomach and serves as an effective palpator during the fluoroscopic phases of small intestinal studies.—*Harold C. Hamilton, M.D.*

Tainsh, L. Campbell, and Medhurst, Geoffrey. The demonstration and pathology of Meckel's diverticulum; with report of a case. *Brit. J. Radiol.*, July, 1955, *28*, 351–354. (From: Department of Radiology, Croydon General Hospital, Croydon, England.)

The authors review the embryology and anatomy of Meckel's diverticulum. Approximately three times as many males as females are affected. Among the complications which have been reported are acute inflammation, acute intestinal obstruction, intussusception, hemorrhage, new growths, tuberculosis, regional ileitis, and foreign body perforation.

If the diagnosis of Meckel's diverticulum is suspected, the authors believe that hourly or half-hourly films should be taken during the gastrointestinal examination, together with careful fluoroscopy. The diagnosis has also been made by barium enema, and from recognition of a gas-filled sac in the plain film. A case is reported in which the barium-filled diverticulum was clearly demonstrated in the four hour film in a thirty-three year old female being examined because of abdominal pain, frequency of micturition, and vomiting.—*B. Aramsri, M.D.*

McGee, A. R., and Rapp, C. R. (Toronto, Ontario.) Sarcoidosis of the rectum. *J. Canad. A. Radiologists*, June, 1955, *6*, 29–32.

The authors report a case of sarcoidosis of the rectum which they believe is the first such case described. They briefly review the historical, pathological, and clinical features of sarcoidosis.

The patient was a man 26 years old who gave a four-year history of increasing constipation producing ribbon-like stools. A large, firm, locular, nodular, nontender mass was found on the posterior and lateral wall of the rectum on digital examination. A barium enema study showed a narrowing of the rectum over a two-inch length. Chest and hand roentgenograms were negative. All laboratory findings were normal. Biopsy revealed a "nodular granuloma of non-specific type"—diagnosed as sarcoid.

A Devine defunctioning colostomy was performed. A barium enema examination three months later showed no change in the rectum. Two years later no evidence of the disease could be found, and the patient therefore had the continuity of the bowel restored. The patient remained in good health throughout three years of observation following the second operation.—*L. E. Sargent, M.D.*

Figiel, Leo S., and Figiel, Steven J. Perforation of necrotizing primary retroperitoneal tumors into the gastrointestinal tract. *Radiology*, Aug., 1955, *65*, 227–230. (From: Division of Radiology, Grace Hospital, Detroit, Mich.)

Perforation of a necrotizing primary retroperitoneal neoplasm with resultant fistulous communication with the gastrointestinal tract is a rare occurrence. The first two such cases which have been roentgenographically documented are presented. In one of these cases, a fistulous communication between the the third portion of the duodenum and the air-filled portion of a retroperitoneal sarcoma was demonstrated, and in the other, the centrally degenerated portion of a retroperitoneal neurogenic sarcoma was found to communicate with the jejunum.

According to the authors, the diagnosis of necrotizing retroperitoneal tumor with perforation into the gastrointestinal tract is possible under the following circumstances:

1. When a scout film of the abdomen demonstrates a soft tissue mass within which is a pocket of gas.

2. When complete gastrointestinal studies demonstrate the presence of a space-occupying intra-abdominal mass which displaces segments of the alimentary tract and a portion of which contains barium and/or gas, indicating the presence of a fistulous communication.

Differential diagnosis includes tuberculous or fungus abscess, regional ileitis, perforation of a Meckel's diverticulum, or bowel perforation by a foreign body. These conditions may be difficult to differentiate, but in such cases one would expect a gross alteration of the small bowel pattern rather than a more or less localized mucosal change at the site of perforation. The demonstration of a thickly marginated wall bordering a gas pocket should exclude with reasonable certainty such possibilities as a diverticulum or reduplication of the gastrointestinal tract. The rare circumstance of malignant invasion or degeneration in a large duodenal diverticulum might under certain circumstances present problems in differential diagnosis.—*A. Ralph Watson, M.D.*

Carlson, Everett, Gates, C. Y., and Novacovich, George. Spontaneous fistulas between the gallbladder and gastrointestinal tract. *Surg., Gynec. & Obst.*, Sept., 1955, *101*, 321–330. (From: The Surgical Services of Mary's Help Hospital and The St. Francis Hospital, San Francisco, Calif.)

Some degree of liver damage invariably results from long standing artificially made anastomosis between gallbladder and upper gastrointestinal tract. Spontaneous fistulas between gallbladder and adjacent viscera expose the patient to the same

liver complications. Thirteen cases of spontaneous fistulas involving gallbladder were reviewed. Ten of these were between gallbladder and duodenum, two between gallbladder and stomach, and one between gallbladder and colon.

The most common cause of the fistulas is gallstone perforation, and this was believed to be the cause in all 13 of these cases. In six of these, operation for gallstone ileus was necessary. Perforated peptic ulcer and cancer may cause fistula, but do so much less frequently than stones.

In 2 cases long periods (16 years and 7 years) had elapsed before complications of the persistent fistula developed which required surgery. In two cases malignant change occurred and in one, cirrhosis developed.

The fistulas may close spontaneously. Some degree of liver damage probably occurs in all.

Some of the cases were overlooked in spite of clinical and roentgenologic investigation. Reflux of barium into the gallbladder, air in the biliary tree, and dysfunction or nonvisualization of the gallbladder with the opaque medium were important diagnostic findings.

Treatment must be individualized. The aim should be relief of ileus, removal of diseased gallbladder and stones, closure of the gastrointestinal defect, exploration of common duct if the patient is jaundiced. In poor risk patients, two operations may be advisable.—*Lois Cowan Collins, M.D.*

Samuel, Eric. (Johannesburg, South Africa.) The post-cholecystectomy syndrome. *Brit. J. Radiol.*, Sept., 1955, *28*, 482–494.

The postcholecystectomy syndrome has been loosely applied to symptoms which occur after cholecystectomy. Some writers say that this syndrome is seen after 20 per cent of cholecystectomies. Since the advent of intravenous contrast media capable of demonstrating bile ducts it has been possible to study dilatation of the hepatic ducts and the size of the common bile duct. Preoperative dilatation and the abscence of constant postoperative dilatation of the bile ducts makes it questionable whether dilatation after cholecystectomy does not indicate a pathologic change rather than a compensatory function. The author believes that alteration in the function of the sphincters may not necessarily be a postcholecystectomy sequel but rather a preoperative undetected finding.

Thirty-six patients with symptoms labeled postcholecystectomy syndrome are analyzed in this article.

The author lists the symptoms which presented most frequently in the following order: (1) pain was by far the most frequent symptom. This was either a severe colicky type of pain or intense right hypochondrial pain; (2) distention usually occurred after pain and was associated with biliousness; (3) jaundice was not a frequent sign and only four patients noted attacks of jaundice; (4) temperature occurred in only one case in this series; (5) indigestion presented in six cases.

The roentgenographic anatomy following cholecystectomy is described in detail. It is pointed out that the fading of the shadow of the lower end of the common bile duct during cholangiography is to be considered as a normal finding. The funnel-shaped tapering shadow was seen in 24 of the 36 cases reported. A dilated cigar-shaped termination clearly seen as far as the medial wall of the duodenum was regarded as pathological and usually was associated with some obstruction at the sphincter. It is the author's definite impression that the majority of dilated ducts are either the result of obstruction or infection, or were actually dilated preoperatively. Cystic duct remnants were demonstrated by cholangiography in five cases in this series.

Case histories, clinical and roentgenological findings are listed in great detail. The article is profusely illustrated with reproductions of roentgenograms and line drawings.—*Richard E. Kinzer, M.D.*

Moes, C. A. F. (Toronto, Ontario.) Investigation of the accuracy of cholecystography. *J. Canad. A. Radiologists*, June, 1955, *6*, 33–34.

The author reviews two hundred cases, which had been examined by means of oral cholangiography and which had subsequently undergone surgery.

When either opaque or nonopaque calculi were demonstrated roentgenographically they were found at operation in one hundred per cent of cases. In the group of 64 patients in which a roentgen diagnosis of a nonfunctioning gallbladder without visible stones was made, 83 per cent revealed stones at operation; 95 per cent of this group had a definite pathological lesion. In the group of eight cases in which a roentgen diagnosis of a malfunctioning gallbladder without stones was made, stones were found in five at operation; however, all eight gallbladders were pathological.

The author lists the various extracholecystic causes of poor or nonvisualization of the gallbladder. He stresses the necessity of repeating the examination when the gallbladder is nonfunctioning, and the advisability of taking films with the patient in various positions.

Several roentgenographic reproductions illustrating calculi by study in upright or lateral recumbent positions when not visualized in routine position are included.—*H. J. Teufen, M.D.*

Aldridge, N. H. Rapid examination of the biliary tract; a new technique with biligrafin. *J. Fac. Radiologists*, April, 1955, *6*, 243–253.

(From: Diagnostic X-Ray Department, The General Infirmary, Leeds, England.)

There are two disadvantages in the oral use of a contrast medium for gallbladder visualization: the dose absorbed by the patient is unpredictable and may be negligible; toxic reactions occur in a significant percentage of cases, with nausea, vomiting and diarrhea. In order to increase the rapidity with which the gallbladder could be demonstrated, completing the examination in 45 minutes instead of 120 to 150 minutes as usually required, and to improve the technique of demonstration of the gallbladder and the bile ducts, the author investigated the use of biligrafin in 100 cases referred for examination of the biliary tract. Also, to determine the value of biligrafin in patients with jaundice, 15 such cases were examined. In the absence of disturbances of liver function, only about 10 per cent of the contrast medium is excreted through the renal system. When excretion by way of the liver is impaired a persistent pyelogram may be obtained. The author quotes Frommhold as having found that in rabbits the highest concentrations in the liver bile were obtained about ten minutes after injection, and that further clinical experiments suggested that these results were applicable in humans.

Newman is quoted as having shown that a thin watery bile is continually being secreted by the liver, and as this flows into the bile ducts mucus is added to it. If the sphincter of Oddi is closed, the dilute bile enters the gallbladder by flowing up the cystic duct. As the gallbladder concentrates this bile, the intracystic pressure falls below that of the bile ducts and more thin bile is drawn from the ducts. As the gallbladder fills with concentrated bile the pressure within it gradually increases. Concurrently the intraductal pressure rises until the sphincter of Oddi relaxes, allowing liver bile to drip into the duodenum. After injection of a contrast medium (biligrafin), if the gallbaldder already contains concentrated bile, little opaque medium contained in the thin bile in the ducts will diffuse into it, and therefore a relatively long time will be required for enough contrst medium to enter the gallbladder to produce a diagnostic shadow. Hence, the gallbladder is usually not well shown until about two hours after injection of the biligrafin.

In an attempt to evacuate the contentrated non-opaque bile from the gallbladder before using biligrafin, a preliminary fatty meal was given 1½ hours before the examination and in all cases improved early filling of the gallbladder was obtained, provided that the sphincter of Oddi remained closed. To prevent the sphincter of Oddi from relaxing until the gallbladder had filled with opaque medium, thus making certain that the biliary pressure was raised above the intracystic pressure, while the medium was being excreted in high concentration by the liver, the effects of pethidine were studied. This agent was found to be as effective as morphine in causing the sphincter of Oddi to contract, but there were no side effects. The duration of spasm did not last longer than 45 minutes when 25–50 mg. was given intravenously, and there was no inconvenience to the patient if it was given slowly. The author found that even 20 cc. of biligrafin intravenously produced better contrast by using the above method than 40 cc. with previously published methods.

In erect films taken soon after the injection of biligrafin, layers of stratification may be seen in the gallbladder and these must be distinguished from floating calculi or biliary "sand." Usually, three distinct layers are seen, the lowest being most radiopaque, that above it relatively translucent, and an upper layer of density intermediate between these two, probably representing layers of bile of different specific gravities. In early films taken in the prone position a dense rim of medium is often seen toward the fundus of the gallbladder. This may be due to active concentration of medium by the wall of the gallbladder. In cases where both contractility and ability to concentrate have been lost, filling may be delayed, probably because the first fatty meal did not cause evacuation of the full gallbladder. The absence of concentration may be shown by taking serial films: No decrease in the size of the gallbladder occurs and the density of the contrast medium remains little altered. Absence of stratification in erect films and of dense rim shadows in prone films may be supporting evidence of inability to concentrate the medium.

In 15 jaundiced patients, some demonstration of the biliary system after injection of biligrafin was obtained in 6, and in 5 of these calculi were revealed in the common bile duct. In the 9 cases which failed to show filling, 8 had moderate to severe liver dysfunction in biochemical tests.—*Samuel G. Henderson, M.D.*

Eisen, David. (Toronto, Ontario.) Operative cholangiography. *J. Canad. A. Radiologists*, June, 1955, *6*, 21–24.

Operative cholangiography is not a new procedure but has been in use for more than 25 years. In spite of this, and in spite of its known value, it has been employed only sporadically in most institutions. The author points out that it has been routine practice at the New Mount Sinai Hospital for two years.

The surgical part of the technique is described in detail. Diodrast 35 per cent is used and it is suggested that a ureteral catheter threaded into the cystic duct and tied in is perhaps the best method. The first injection usually consists of 3 to 5 cc. of the opaque solution, and the second injection is intended to completely fill the bile ducts and demonstrate patency or obstruction.

The role of the anesthetist is described. The anesthetist, the x-ray technician, and the surgeon must work as a team in order to produce satisfactory films. It is brought out that the radiologist must also be close at hand for supervision and interpretation of films as soon as they are available for examination.

The roentgen findings in a series of cases are described in detail. The author states that these case reports were chosen to illustrate several principles. He notes that a calculus may be present without being suspected and that jaundice need not be present with duct stones. He points out that large stones need not necessarily obstruct the duct and that normal sized ducts may contain numerous stones.—*Richard E. Kinzer, M.D.*

REICHELDERFER, THOMAS E., and VAN HARTESVELDT, JOYCE. Intravenous cholecystography with cholografin in infants. *A.M.A. Am. J. Dis. Child.*, May, 1955, *89*, 591–595. (From: Departments of Pediatrics and Radiology, The Johns Hopkins Hospital, and Division of Maternal and Child Health, School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, Md.)

The authors present data obtained in infants in the comparison of the oral and intravenous methods of cholecystography. The oral method using iodopanoic acid gave satisfactory visualization in 47 per cent of infants under three months of age, in 60 per cent between the ages of four and six months, in 54 per cent in the group from seven–twelve months of age and in 93 per cent in the twelve–twenty-four month age group.

The cholografin series included 12 patients under the age of one year. Visualization was satisfactory in 50 per cent of the age group from zero–three months and 100 per cent in the 6 cases ranging from four to twelve months of age. Visualization of the extrahepatic ducts was not obtained in any infants. There was no evidence that the material was being excreted by the kidney.

No untoward reactions or toxic effects of the drug were encountered in either series. Infants are able to excrete contrast material from the liver. Function appears to improve as the infant matures.—*James F. Martin, M.D.*

WHITEHOUSE, WALTER M., and MARTIN, O. Clinical and roentgenologic evaluation of routine 2-gram telepaque dosage in cholecystography. *Radiology*, Sept., 1955, *65*, 422–424. (From: Department of Radiology, University Hospital, Ann Arbor, Mich.)

Because of dense gallbladder shadows and a high incidence of unabsorbed contrast material in the colon following ingestion of telepaque in 3-gram doses, a study was made to determine if a smaller dosage was indicated. Consequently 500 gallbladder examinations using 2-gram dosage of telepaque were done.

The incidence of side-effects was compared with an earlier series studied with priodax and telepaque in 3-gram dosages. The more frequently encountered side-effects of mild diarrhea and mild dysuria were reduced 4 to 5 per cent as compared with the earlier series. A reduction in the number of extremely dense gallbladder shadows was noted, but the over-all decrease of satisfactory diagnostic shadows was only 4 per cent. The authors feel that this is counterbalanced by the decreased risk of obscuring biliary calculi by the extremely dense shadows more frequently seen with the 3-gram dosage.

No adjustment in dosage to the weight of the individual was found to be necessary as satisfactory gallbladder densities were obtained over the entire clinically encountered range of patient weights.—*Donald N. Dysart, M.D.*

WHITEHOUSE, WALTER M. A comparative clinical study of teridax (3 gm.) and telepaque (2 gm.) in routine cholecystography. *Radiology*, Sept., 1955, *65*, 425–428. (From: Department of Radiology, University Hospital, Ann Arbor, Mich.)

With the introduction of a new cholecystographic medium teridax—3(3 hydroxy-2,4,6 triiodophenyl) 2-ethyl propionic acid, a study was undertaken to compare its results with a previous series using telepaque—3(3 amino-2,4,6 triiodophenyl) 2-ethyl propionic acid. Dosages used in this study were teridax-3 gm. and telepaque-2 gm.

The incidence of side reactions of nausea, vomiting, diarrhea, dysuria and others were tabulated and classified as to whether they were mild or severe. It was found that the incidence of asymptomatic patients was higher with 3 gm. of teridax (71 per cent) than with 2 gm. of telepaque (66.2 per cent). The incidence of diarrhea was decreased.

Gallbladder visualization was classified as excellent (a dense gallbladder shadow), good (a diagnostic shadow which is not dense), faint, and non-visualization. The number of dense shadows was markedly reduced in comparison with telepaque, but the incidence of faintly and non-visualized gallbladders was more than doubled. Whether this more nearly represents the variation of function of the gallbladder can only be decided after study of larger series of gallbladder examinations correlated with surgical pathological material.

Residual contrast medium in the colon was found in very few of the patients examined with teridax, while 97.4 per cent of the patients showed this residual following ingestion of 2 gm. of telepaque. This residual is not felt to be confusing and in the pa-

tients with a nonfunctioning gallbladder, served as a visual indication that the medium was ingested.

In conclusion the author states that in spite of the decreased side-effects with teridax in 3-gm. dosage, the diminution in gallbladder density increases the number of faintly and non-visualized gallbladders to such a degree that telepaque in 2-gm. dosage remains the oral cholecystographic medium of choice for routine work.—*Donald N. Dysart, M.D.*

Genitourinary System

Lowman, Robert M., Shapiro, Harrison, and Newman, Harry R. Clinical experiences with hypaque sodium 50% in intravenous urography. *Canad. M. A. J.*, Aug. 15, 1955, *73*, 264–269. (From: Department of Radiology and Urology, Memorial Unit, Yale Medical Center, Grace-New Haven Community Hospital, Yale University School of Medicine, New Haven, Conn.)

A new compound for intravenous urography, designated as hypaque, in 50 per cent solution, was tested in 400 cases. Examinations were discouraged in patients with significant allergic histories, and all patients were tested by one or more of the following methods: ocular, oral, dermal, or intravenous. In all, only 22 reactions were encountered in 400 patients (5.5 per cent). In the most recent 100 cases, 9 reactions occurred in 6 patients. In these 100 cases there were 13 allergic histories and 4 of the 6 patients with reactions fell into this group with allergic histories. In one patient (without allergic history) the reaction consisted of transient shoulder pain, which merely represents local reaction. Of the 6 patients having reactions, only one had a positive preliminary test, and she was therefore not subjected to examination. This incidence of reaction is lower than that reported by others on a series of 5,694 patients receiving urokon 30 per cent, diodrast 35 per cent, and neo-iopax 50 per cent, in which an incidence of 17.3 per cent reactions was encountered. Another series using these media, and also chlortrimetron, had an incidence of 7.1 per cent reactions.

In general, a marked improvement in diagnostic quality of these examinations, as compared to those carried out with media of lower iodine concentration, was apparent. The authors conclude that hypaque 50 per cent is of low toxicity and a very satisfactory urographic medium.—*Lois Cowan Collins, M.D.*

Bodner, Henry, Howard, Allan H., and Kaplan, Joseph H. Hypaque, a new urographic medium: preliminary report on 300 cases. *J. Urol.*, Sept., 1955, *74*, 422–426. (Address, Dr. Bodner, 6333 Wilshire Blvd., Los Angeles, Calif.)

The authors present a preliminary report on the use of hypaque for intravenous urography in 300 consecutive patients. The molecular iodine content of this drug in a 50 per cent solution is 59.87 per cent. This compares favorably with 70 per cent urokon. Toxicity studies have shown that tolerance for hypaque is greater than for urokon or diodrast as studied in the experimental animals. Approximately 90 per cent of the drug is excreted with inthe first twenty-four hours. The drug does not produce any greater vein irritation than is produced by diodrast or 30 per cent urokon.

The authors prepared the patients in the customary way, but usually without catharsis and with the addition of 60 gr. of sodium bicarbonate, the evening before and the morning of the day of the roentgen-ray examination. Approximately 20 to 30 cc. of hypaque were injected intravenously using a 22 gauge needle as rapidly as the operator could force the solution through this needle. Films were taken as indicated. Reactions were comparatively few and all were mild with the exception of one patient who had moderately severe urticaria, flushing and sneezing. The roentgenograms were graded by three different examiners. Of the film studies 72.6 per cent were excellent, 18.6 per cent were good, 5.4 per cent were fair and 3.4 per cent were poor.

Several tables are given to indicate the age distribution of the patients, the diagnosis and the reactions which occurred with hypaque as compared to other commonly used media. The authors believe that hypaque is a superior material which is easily administered, affords excellent contrast, has fewer undesirable side effects, and results in a higher percentage of diagnostic films. They point out, however, that a larger series of cases over a longer period of time is necessary for a more accurate statistical study.—*George Chamberlin, M.D.*

Harrow, Benedict R. Intravenous urography using mixtures of radiopaque agents. *Radiology*, Aug., 1955, *65*, 265–270. (From: Department of Urology, Mercy Hospital, Miami, Fla.)

In an attempt to produce intravenous urograms of the density of retrograde films, the author has tried combining two radiopaque agents in order to increase the concentration of iodine in the urine. Fifteen cc. of 35 per cent diodrast mixed with 15 cc. of 50 per cent neo-iopax and injected slowly over a five to 6 minute period produced a slight but definite increase in the density of the roentgen shadow. This was greater than that seen when 30 cc. of either solution alone was used. Side reactions have been less with the mixture and it has been proved to be safe.

Greater amounts of the mixture have also been used with increased roentgen density of the urinary tract. Another medium, 70 per cent urokon, alone gave much greater density than similar amounts of

30 per cent urokon, 35 per cent diodrast or 50 per cent neo-iopax, but the incidence of side effects was greater. Mixtures of urokon and neo-iopax have not been tried yet.

The physiology of the excretion of these media is discussed as is the technique for urography. Careful preparation by dehydration for sixteen to eighteen hours is stressed, and adequate compression with accurate positioning is necessary for obtaining high quality films.—*Donald N. Dysart, M.D.*

Winter, Chester C. The value of chlor-trimeton in the prevention of immediate reactions to 70 per cent urokon. *J. Urol.*, Sept., 1955, *74*, 416–421. (From: Division of Urology, Veterans Administration Center, and University of California Medical Center, Los Angeles, Calif.)

The author has divided 900 patients into 2 equal major groups: (1) those receiving 25 cc. of 70 per cent urokon alone and (2) those receiving the same medium with the addition of 10 mg. of chlor-trimeton. Each major group was then subdivided into individuals with and without an allergic background. Initially all patients were tested for drug sensitivity by injecting 1 cc. of 70 per cent urokon intravenously and observing the patients for ten minutes or longer. This was abandoned after 200 consecutive negative tests.

The reactions of the patients were classified into 3 groups: Urticaria, asthma, dyspnea and sneezing were interpreted as allergic reactions; pain, venous spasm, flushing and dizziness were considered neurovascular reactions; and nausea and vomiting signified psychogenic reactions. The addition of chlor-trimeton to urokon decreased nausea, probably because of its cerebral sedative effect. In the neurovascular group, venous spasm was unaffected by chlor-trimeton; however, flushing was not observed in these patients. This also might be explained by the sedative quality of the drug. Among the patients with an allergic history the incidence of urticaria was reduced twofold by the addition of chlor-trimeton whereas among the nonallergic persons it was reduced threefold. Furthermore, among patients in whom urticaria developed from urokon alone, the symptoms were rapidly dissipated by the adminstration of intravenous chlor-trimeton.

Of the 900 cases included in this study only 1 showed a serious reaction. This occurred in a patient with a nonallergic history who received the urokon-chlor-trimeton mixture and rapidly went into a state of shock. His peripheral pulse and blood vessels were unobtainable, although cardiac action was identified. He was treated by oxygen, intravenous chlor-trimeton (100 mg.) and epinephrine with good results in fifteen minutes.

The author concludes that the addition of 10 mg. of chlor-trimeton to the urographic media produces significant reduction in the allergic reactions to the drug. At the present time there appears to be no correlation between the currently used sensitivity tests and predictability of reaction to urographic media.—*George Chamberlin, M.D.*

Allen, R. Parker. Neuromuscular disorders of the urinary tract in children. *Radiology*, Sept., 1955, *65*, 325–333. (From: Children's Hospital, Denver, Colo.)

Many of the disorders of the urinary tract in children have some neurogenic basis. The neuromuscular disease may be congenital or acquired, extrinsic or intrinsic. Among the congenital extrinsic causes are cerebral palsy, neurovertebral malformations, meningocele, amyotonia, and congenital syphilis. Acquired extrinsic causes include syringomyelia, poliomyelitis, muscular atrophy, cord injury, and cord tumors. In most of these conditions the urinary tract is not affected without easily recognized signs of general involvement being apparent. Intrinsic neuromotor disorders may be present, however, without visible congenital defect and without extra-urinary signs. These are sometimes found in conjunction with other neuromotor abnormalities, such as megacolon, small bowel aganglionosis, regional ileitis, or aclasia. Cases with involvement of the urinary tract alone are the most difficult to diagnose and treat.

Those urinary disorders which have definite associated clinical disease present practically no diagnostic problem except the determination of how much of the difficulty is due to the neurological disorder, and how much to subsequent infection and obstruction. Disorders of the urinary tract associated with some abnormality such as megacolon may usually be presumed to be on a neuromuscular basis, since about 50 per cent of patients with Hirschsprung's disease will have some urinary dysfunction. In the remaining group of neurogenic disorders the diagnosis is not easy, though certain procedures will often be of aid. Physical examination is, of course, always of importance, and scout films of the abdomen, cystography, urethrograms, urograms, and the determination of residual urine will usually give the needed information for accurate diagnosis. The author discusses in detail the use of these various procedures in relation to diagnosis in these neuromuscular conditions.

Eight illustrative cases are presented, and treatment is briefly discussed.—*A. Ralph Watson, M.D.*

Demoullin, M., and Nickels, L. Kelchzysten der Niere. (Calyceal cysts of the kidney.) *Fortschr. a.d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, Aug., 1955, *83*, 208–213. (Address: Dr. Demoullin, Service de radiologie et de radiothérapie, Hôpital de la Ville, Esch/Alzette, Luxembourg.)

The term "calyceal cysts" (described in the French literature variously as hydrocalyx, cystic calyceal dilatation, cystic calyceal diverticulum, etc.) refers to rounded, perfectly circumscribed, smooth walled spaces (diverticula), connected to the calyx by a pedunculated communication, which explains their filling with contrast material after intravenous or retrograde procedures. This malformation is rarely encountered, but it must be recognized, to avoid nephrectomy for an otherwise well-functioning kidney. In the few cases in which surgery appears indicated, local resection is adequate.

The symptomatology is nonspecific, such as vague unilateral lumbar pain, sometimes associated with hematuria. The four observations reported in this article are in females, but males are also affected. In uncomplicated cases, autopsy reveals the diverticulum to be carved in renal parenchyma, its mucous membrane being a direct continuation of the inner calyceal covering; often, though, inflammatory changes are seen; if a narrow peduncle favors stasis, inflammation (callico-papillitis) will result in hematuria and accumulation of concretions; if the communication is obliterated, a "parenchymal" renal calculus will be the final stage.

The smooth diverticular contours, and the frequent presence of calculi, make possible the differentiation from cavities of pyogenic or tuberculous etiology. In the latter case, one finds usually other evidence of pathology as well, for instance the typical papillary calcifications. In polycystic disease, the cysts are located in the cortex; furthermore, the enlarged kidney causes the well known elongation and displacement of the pelvis. The only pathologic appearance similar to the diverticulum is the persistent hydrocalyx, caused by incomplete obstruction of the infundibular exit, either functional or by stenosis and/or calculus.—*E. R. N. Grigg, M.D.*

Baker, William J., Portney, Fred R., and Firfer, Raymond. A study of x-ray hazards of retrograde urography. *J. Urol.*, July, 1955, *74*, 174–175. (From: Cook County Hospital Urological Department, Chicago, Ill.)

Simple tests for roentgenographic exposures, including the use of a dental film placed on the abdomen and hand, and a roentgen-ray dosimeter, were performed by the authors. These tests were done under actual working conditions during which time the urologist was in close proximity to the ureteral catheters. Three films were made for each individual pyelographic study.

It was found that the abdominal exposure to the operator averaged 1,200 mr and the exposure on the hands was as much as 3,200 mr.

The authors advise the following precautions: The urologist should leave the room during the exposure of the scout films; he should wear a thin lead apron, and a thin lead shield should be placed between the physician's hands and the path of the roentgen ray. With these simple protective measures the exposure to the urologist was found to be insignificant.—*George Chamberlin, M.D.*

Goodwin, Willard E., Moore, E. Vincent, and Peirce, E. Converse, II. Roentgenographic visualization of adrenal glands: Use of aortography and/or retroperitoneal pneumography to visualize adrenal glands: "Combined adrenalography." *J. Urol.*, Aug., 1955, *74*, 231–242. (From: Division of Urology, University of California Medical Center, and Veterans Administration Center, Los Angeles, California, and The Acuff Clinic, Knoxville, Tenn.)

In selected patients, when special preoperative study of the adrenals is indicated, the use of combined retroperitoneal insufflation and aortography has resulted in a definitive diagnosis in many instances.

The authors report 8 patients in detail from the numerous cases which they have previously studied. The techniques of retroperitoneal air insufflation and aortography have been previously described. The film examination consists of an anteroposterior, posteroanterior, right and left oblique position. By this method the authors have been able to demonstrate the arterial supply to the normal and abnormal adrenal glands.

A brief discussion of adrenal hyperplasia, calcification and tumors is presented. In two instances errors in diagnosis were due to an unusual projection of the left lobe of the liver and enlargement of the tail of the pancreas.

The authors suggest that the addition of laminagraphy in certain instances might be of further value but they have not used this procedure in any of the patients which they have studied.—*George Chamberlin, M.D.*

Skeletal System

Gershon-Cohen, J., Schraer, Harald, and Blumberg, Nathan. Bone density measurements of osteoporosis in the aged. *Radiology*, Sept., 1955, *65*, 416–419. (From: Albert Einstein Medical Center, Northern Division, and Home for the Jewish Aged, Philadelphia, Penna.)

The authors obtained density coefficients of bone mineralization in 149 aged individuals, ranging from sixty-three to ninety-eight years of age. These objective measurements were obtained with a modified densitometer and computation equipment consisting of a function transformer and recording, integrating, and counting devices. Individual determinations were compared with clinical roentgen estimates of

osteoporosis. There was good correlation in the studies of the os calcis and the middle phalanx of the fifth finger. Correlation was poor when the same physical measurements were compared with the degree of clinical osteoporosis of the spine.

Records of individual density coefficients in the aged are highly reproducible and make possible a better appraisal of the degree of osteoporosis in relation to such factors as time, nutrition and mineral and hormone balance.—*A. W. Sommer, M.D.*

GRUNOW, OTTO H. Radiating spicules, a nonspecific sign of bone disease. *Radiology*, Aug., 1955, *65*, 200–205. (Address: 650 Fifth Avenue, Fort Worth, Texas.)

The more common roentgenographic evidences of bone tumor, besides destruction, are spiculation, periosteal lipping, and layering of bone. Spiculation (arborization, sunburst ray formation, sun ray) is commonly associated with osteosarcoma, but it has been described in many diseases other than osteosarcoma. Spicule formation is primarily an attempt at repair by a periosteum which is elevated by an expanding process. It represents a nonspecific manifestation of bone disease. The spicules are variable in character, being perpendicular to the cortex, slightly angulated or flowing. They may be short or long, fine or coarse, few in number or forming a well developed palisade. Besides radiating outward, they may radiate inward into the medullary canal.

Spiculation may occur in Ewing's sarcoma, chondrosarcoma and occasionally in bone lesions metastatic from the alimentary tract. Meningioma has frequently been known to result in spicule formation. Prostatic carcinoma, testicular tumors, chloromas and neuroblastoma have been found to produce a similar appearance. Syphilis, chronic osteomyelitis and chronic hemolytic anemia may at times result in a definite ray formation.

Since spiculation has been described in many diseases other than osteosarcoma and is infrequently seen in that disease, it is reasonable to assume that spiculations, per se, should no longer be considered as diagnostic evidence of primary bone tumor.—*A. W. Sommer, M.D.*

STEINERT, RAGNAR. Osteochondrosis in the cervical spine. *Radiology*, Sept., 1955, *65*, 412–415. (Address: Røntgenavdelingen, Akershus Fylkessykehus, Midtstua, Oslo, Norway.)

Two groups of patients were studied to determine the relationship between roentgenologically demonstrable degenerative changes of the cervical spine and symptoms of cervical or brachial neuralgia. From among the patients of a roentgenologic department, a group of 320 subjects was chosen having widely different diseases without any relation to the cervical spine. Roentgenograms of the cervical spine of these subjects were made in the erect lateral and both oblique positions and they were questioned regarding past or present brachial neuralgia or history of pain and stiffness in the neck, pain in the back of the head, or radiating pain to the shoulder and arm with or without paresthesia in the fingers. The other groups consisted of 77 healthy soldiers between 18 and 30 years of age who had never had any symptoms of brachial neuralgia. Only lateral roentgenograms were taken in this group to investigate the usual dimensions of the disk spaces at different levels in presumably normal subjects in whom it was assumed that roentgenologically visible degenerative findings have not yet developed. Eleven of this group were found to have one disk a little thinner than the one above, and it was concluded that a single thin disk without other pathological roentgen findings could be considered normal

It was found that roentgenologically demonstrable degenerative lesions of the cervical spine occurred as often in persons with as without symptoms, 73 and 75 per cent, respectively. These abnormalities increase with age and are nearly always present in persons over sixty years old. The most common lesion encountered was destruction of the disks with narrowing of the intervertebral foramina.—*Harold C. Hamilton, M.D.*

ROWLEY, K. A. Coronal cleft vertebra. *J. Fac. Radiologists*, April, 1955, *6*, 267–274. (From: St. Mary's Hospitals for Women and Children, Manchester, England.)

The persistence of anterior and posterior ossification centers in dorsal and lumbar vertebral bodies beyond the age at which multiple centers when they occur would normally have united (16 weeks intrauterine life), termed "coronal cleft vertebra," is described, illustrated and discussed.

Coronal cleft vertebrae were found in 15 living infants and 13 still born fetuses, 25 of whom were males. Antenatal diagnosis was possible in 16 instances, and in 11 cases the progress of ossification was observed roentgenologically. More than one vertebra showed the cleft in just over 50 per cent of this series, and once the condition is appreciated it is unlikely to be confused with any significant developmental anomaly, or with any acquired lesion. Multiple involvement, the typical situation toward the posterior aspect of the lumbar (more rarely dorsal) vertebrae, the increased anteroposterior diameter of the vertebra, the constant linear or oval shape of the defect with reasonably well defined margins and normal intervertebral spacing are all features which assist in the differentiation from an acquired lesion. The absence of any clinical features and the progression to normal appearances on follow-up examination confirm the diagnosis. In the great majority of these cases normal consolidation of

affected vertebrae is to be expected within a few months.—*Samuel G. Henderson, M.D.*

Feld, Harold, Switzer, Robert A., Dexter, Morris W., and Langer, Edward M. Familial metaphyseal dysplasia. *Radiology*, Aug., 1955, *65*, 206–212. (From: VA Center, Bay Pines, Fla.)

This article reports two cases of familial metaphyseal dysplasia involving a brother and sister. In both patients there was a widening of the metaphyseal ends of the long bones, with cortical narrowing and a ground-glass appearance of the medullary portions, together with hyperplasia or aplasia of the paranasal sinuses and the cells in the temporal bones. The cases presented certain findings not previously reported. There was decrease in the transverse diameter of the base of the skull and the transverse diameter of the pelvis. In one patient there was widening of the ischia and the pubic bones and thickening of the dorsum sellae. In the other patient, there was intrapelvic protrusion of the acetabula. The femoral necks were thickened, with bilateral coxa valga deformities.

Familial metaphyseal dysplasia produces a unique and characteristic appearance of the bones and should not be difficult to differentiate from other conditions.—*A. W. Sommer, M.D.*

Chauss, Jay M. Chondroectodermal dysplasia (Ellis-van Creveld disease); a case report. *Radiology*, Aug., 1955, *65*, 213–217. (From: Department of Radiology, St. Francis Hospital, Olean, N. Y.)

The sixth case of chondroectodermal dysplasia to appear in the literature is described by the author. The condition was recognized shortly after birth. Death (apparently due to cardiac failure) occurred at the age of twenty-nine weeks.

The most typical features of the syndrome were present in this case, including polydactylism of the hands with symmetacarpalism, progressive distalward shortening of the tubular bones, and hypoplasia of the nails. The teeth were expected to have shown typical dysplasia because of the appearance of the gums. According to Caffey, bilateral fusion of the capitate and hamate bones, retarded maturation of the primary ossification centers in the epiphyseal cartilages, 'and characteristic deformities in the proximal ends of the tibiae and ulnae and the distal ends of the radii are also consistent findings in this condition. In the present reported case the patient was too young for evaluation of these latter findings.

Inconsistent findings which may be noted in chondroectodermal dysplasia are alopecia, fusion of the upper lip and its gum, congenital malformation of the heart, dislocation of the heads of the radii, retarded maturation of the manual sesamoids, polydactylism and syndactylism in the feet, and polymetatarsalism.

In the case here presented, fusion of the upper lip and gum and congenital malformation of the heart were present.—*A. Ralph Watson, M.D.*

Wilson, Theodore W., and Pugh, David G. Primary reticulum-cell sarcoma of bone with emphasis on roentgen aspects. *Radiology*, Sept., 1955, *65*, 343–351. (Address: Dr. Wilson, The Mayo Clinic, Rochester, Minn.)

Primary reticulum cell sarcoma of bone is a malignant tumor which is characterized by a distinct histopathologic picture and by a clinical course which is relatively benign. It originates at a single site in bone, and when metastasis occurs, it is usually by way of the lymphatics. The prognosis is relatively good, with a five-year survival rate of about 50 per cent following operation or proper irradiation. It is important to distinguish between this tumor and similar, more malignant, tumors such as osteogenic sarcoma and Ewing's tumor.

The authors based their study on a survey of 33 patients with reticulum cell sarcoma. Roentgenograms and pathologic material were available for study in each of these cases.

It was found that 70 per cent of the tumors involved tubular bones, with no definite predilection for any specific portion of bone. Roentgenologically the lesions appeared to be very extensive. Twenty-five to fifty per cent of the bone was often affected by the malignant process, and in some cases the entire shaft was involved. Bone destruction was found to be a predominant and constant feature in primary reticulum cell sarcoma. The diseased bone appeared to blend imperceptibly with normal bone, with no sharp lines of demarcation. In about 45 per cent of the roentgenograms there was some evidence of reactive proliferation of bone. In only 15 per cent was reactive proliferation more prominent than bone destruction. There was cortical destruction in 91 per cent of the series. The more extensive destruction was frequently associated with large soft-tissue masses. Periosteal reaction was observed in 45 per cent of the cases, and 27 per cent of the patients showed definite evidence of cortical thickening. Roentgen evidence of soft-tissue involvement was present in 76 per cent of the cases. Soft tissue calcification was not common. There was evidence of pathologic fracture in about one-fourth of the cases.

It is concluded that, while the roentgenologic appearance of the tumor varies, the radiologist frequently may suspect the diagnosis of reticulum cell sarcoma. He must, however, keep in mind the fact that osteogenic sarcoma, Ewing's tumor, eosinophilic granuloma, and chronic osteomyelitis cannot always be excluded with certainty.—*A. W. Sommer, M.D.*

LEIGH, TED F., KELLY, ROBERT P., and WEENS H. STEPHEN. Spinal osteomyelitis associated with urinary tract infections. *Radiology*, Sept., 1955, *65*, 334–342. (From: Departments of Radiology and Surgery, Emory University School of Medicine, Atlanta, Ga.)

The relationship of urinary tract infection and osteomyelitis of the spine has been realized for several years. This association is explained on the basis of broad communications between the venous plexus of the pelvic organs and the venous plexus enclosing the spinal cord and surrounding the spinal column. That these communications exist has been proved by a thorough anatomic study by Batson. Deviation of the venous blood stream into these vertebral channels may occur during life in the presence of many near-physiologic maneuvers such as straining, coughing, sneezing, and perhaps even abdominal distention.

The authors report a series of nine cases of osteomyelitis of the spine developing during the course of urinary tract infection. Gram-negative bacteria were found to be the offending organisms, in most of these cases. A simple procedure for identifying the causative organism by aspiration biopsy from the involved spinal areas is described. This identification aids greatly in the selection of proper therapy.

Since the roentgen evidence of a lesion in the spine lags some weeks or months behind the clinical manifestations, additional studies at intervals of every few weeks may be necessary to disclose it. The whole spine should be roentgenographed each time as multiple levels are frequently involved. Laminagraphy will frequently reveal obscure and equivocal lesions.

The clinical and roentgen features of this type of osteomyelitis are briefly described.—*Donald N. Dysart, M.D.*

BREITLÄNDER, K. Über Skelettbefunde nach Röntgen-Nahbestrahlung mit grossen Dosen und einen Fall eines Strahlen-Kombinationsschadens (Arsenikpaste). (Skeletal findings following short-distance roentgen therapy with large doses and a case of combined radiation-arsenic paste injury.) *Strahlentherapie*, July, 1955, *97*, 452–458. (From: Strahlen-Abteilung des Auguste-Viktoria-Krankenhauses, Berlin-Schöneberg, Germany.)

Out of many hundreds of patients with skin carcinomas treated with large doses of short-distance roentgen radiation, the author was able to find seven who had received 8,000–40,000 r to single fields immediately underlain by bone. The roentgen technique was: 60 kv., 4 ma., 50 mm. focal-skin distance, 239.4 r/min., and a field diameter of 45 mm. None of these patients showed clinical or roentgen evidence of radiation effect on the underlying bone, *except:* (1) one patient who had slight osteoporosis and periostitis of the dorsum of a metacarpal after 8–10,000 r had been administered to the dorsal cortex of that bone during treatment of a carcinoma; and (2) another patient who had received ten treatments of 500 r each, in a three-week period, and about a month later resorted to the prolonged use of a corrosive arsenic paste locally. The latter patient developed necrosis of skin, subcutaneous tissues, and the outer table of the skull in the treated area, with eventual healing, however.

In adults, serious damage to underlying bone is practically an impossibility in clinical management of superficial carcinomas with short distance roentgen radiation. Whatever latent changes adult bone suffers from radiation doses of 5–20,000 r (these are the estimated doses received by the most superficial layer of bone) always require additional injury (more than mere infection as reported by Regaud) to cause a clinically manifest lesion.—*Henry G. Moehring, M.D.*

ARVIDSSON, H., and JOHANSSON, O. Arthrography of the elbow-joint. *Acta radiol.*, June, 1955, *43*, 445–452. (From: Roentgen Department and Surgical Department, Södersjukhuset, Stockholm, Sweden.)

The authors present a report of some 100 cases of arthrography of the elbow joint to determine soft tissue injury, using a positive contrast medium. Umbradil was injected into the joint space after withdrawal of as much synovial fluid or admixed blood as possible. Roentgenograms were made in the lateral position in flexion and extension, and in anterioposterior and oblique positions.

A normal arthrogram is shown with the normal boundaries of the joint cavity. Pathologic arthrograms were characterized by contrast medium outside the normal boundaries. Fractures of the head and neck of the radius constituted the main part of the material, with ligament-capsule rupture occurring at the medial ligament. In all cases of dislocations of the elbow, the position and extent of the rupture was established. In lateral dislocations, the rupture usually occurred at the medial ligament; in posterior dislocations, there was anterior rupture. There were a number of cases examined in which there were no signs of fracture or dislocation. In this group, there were several with large ruptures of the capsule. The roentgenographic findings were substantiated in those cases which were operated upon.—*Thomas F. Meaney, M.D.*

LAME, EDWIN L. Arthritis of the hip following urinary tract operation. *Radiology*, Aug., 1955, *65*, 194–199. (From: Department of Radiology, Presbyterian Hospital of Philadelphia, Philadelphia, Penna.)

Few cases of destructive hip disease following urinary tract surgery have been reported; the author has reviewed these cases and presents the findings in an additional case. Except in one case, this complication has been associated with osteitis pubis after prostatectomy.

Its etiology is probably a blood borne infection from the common urinary tract organisms (E. coli, Staphylococcus aureus, B. proteus, Pseudomonas aerogenes, and Streptococcus), which persist for long periods, despite pre- and postoperative sulfanilamids and antibiotics. Soft tissue and venous pathways between the inferior pelvis and the hip may explain the pattern of infection spread.

Pathologically, the picture is that of an osteomyelitis, with bone erosion, fragmentation, pus formation and cartilage necrosis. This is associated with the clinical findings of continuous pain in the hip and thigh (aggravated by weight bearing), progressive limitation of motion, with eventual fixation, limp and shortening of the limb, over a period of months to years following prostatectomy. Little systemic reaction has been noted.

Roentgenographically there is a picture of progressive erosive disease of the femoral head and acetabulum identifiable with the changes seen in a pyogenic arthritis. Although it is a very rare entity, its diagnosis should be entertained in postoperative patients with idiopathic hip pain. Vigilance will probably uncover more examples of this disease.—*C. L. Stevenson, M.D.*

Blood and Lymph System

Boerema, I., and Blickman, J. R. Reduced intrathoracic circulation as an aid in angiocardiography; an experimental study. *J. Thoracic Surg.*, Aug., 1955, *30*, 129–142. (From: Surgical Clinic of the University of Amsterdam at the Wilhelmina Gasthuis, Amsterdam, The Netherlands.)

The authors note some of the difficulties with angiocardiography as presently carried out, namely, the rapid dispersion of the contrast medium by the high velocity of the blood stream which necessitates contrast media of high iodine concentration, rapid injection under high pressure, and expensive apparatus for rapid serial exposures. Even very short exposure times do not eliminate much of the haziness due to the motion of walls of the heart and great vessels.

They describe their experimental study of a new method of angiocardiography. Use was made of the slowing of the blood stream through the heart and the fall in blood pressure occurring after increased intrabronchial pressure to values between 40 and 60 cm. of water. It was demonstrated that this slowing down of the blood flow through the heart was primarily caused by compression of the right heart and both venae cavae. Pressure recordings made during this procedure showed that there is no danger of congestion of the right heart. The danger of myocardial ischemia was considered.

In the animal experiments elevated intrabronchial pressures were used for periods up to 60 seconds and no electrocardiographic changes were noted other than temporary reversal of the T wave. Experiments performed in dogs showed that using this technique, clear visualization of the coronary arteries, heart chambers and great vessels is possible with a small amount of contrast medium of low iodine content injected under low pressure with relatively simple roentgenographic equipment.—*Paul C. Olfelt, M.D.*

Cregg, H. A., Smith, P. W., Wilson, C. W., and Bull, J. W. Cardioangiography. *Radiology*, Sept., 1955, 65, 368–372. (Address: Dr. Cregg, Frederick C. Smith Clinic, 240 E. Church St., Marion, Ohio.)

Cardioangiography is a new and experimental method which, if successful, should improve our diagnostic abilities in heart disease. This procedure consists of roentgenography following direct cardiac injection and differs from angiocardiography where the medium is introduced into the heart by way of a vein.

Following the publication of a paper by Ponsdomenech and Beato Núñez of Cuba in 1951, in which they reported on 45 ventricular punctures in 30 humans without mortality, the authors undertook a study of their own.

Seventy-five ventricular punctures in 18 dogs and 8 humans have been carried out. Seventy per cent diodrast was injected into either the right or left ventricle and electrocardiograms were made before, during, and after the procedure. Those dogs that died were autopsied and those that survived were sacrificed and autopsied at intervals ranging from immediately to 53 days after the last puncture. Death occurred immediately in only 1 dog due to ventricular fibrillation following the intramyocardial injection of some medium. Laceration of a coronary artery was prevented by using a subxyphoid approach to the diaphragmatic surface of the heart. Few if any significant changes were found in the autopsied hearts.

In the 8 human cases, one developed ventricular fibrillation which was stopped by cardiac massage. No significant complications occurred in the other 7 patients. Local anesthesia with proper sedation is adequate if the patient can cooperate.

Conditions in which this technique should make the diagnosis easier consist of: pulmonic stenosis, interatrial septal defects, interauricular septal defect with pulmonic stenosis, and tetralogy of Fallot. The aortic and mitral valves and interventricular shunts should be much better visualized.

The authors have not as yet examined any children

or patients with cyanotic heart disease by this method. They also state that they cannot express an opinion concerning its hazards until the method has been more thoroughly evaluated.—*Donald N. Dysart, M.D.*

FLYNN, J. E., SIEBENS, A. A., and WILLIAMS, S. F. Congenital absence of a main branch of the pulmonary artery. *Am. J. M. Sc.*, Dec., 1954, *228*, 673–679. (From: United States Naval Hospital, St. Albans, N. Y.)

The authors add another case of absence of a main branch of the pulmonary artery to the literature.

A twenty-five year old male had several episodes of hemoptysis for which no cause was immediately found. At the age of nine an abnormality of the chest was discovered, but he had enjoyed good health all his life.

On physical examination, the right hemithorax was small with limited motion. On the chest film, there was a shift of the heart and mediastinum to the right with elevation of the right diaphragm. There was no pulmonary artery shadow on the right.

Of particular interest in this case was the use of pulmonary ventilatory studies (including bronchospirometry), cardiac catheterization, and peripheral arterial oxygen concentration studies. From these it was concluded that there must be an absence of the right pulmonary artery. Angiocardiography confirmed this, and also demonstrated a diffuse bronchial artery circulation in the right lung.

The authors postulate that the hemoptysis might have resulted from the rupture of a bronchial artery branch.—*Lawrence A. Davis, M.D.*

DI GUGLIELMO, LUCIO, and GUTTADAURO, MARIANO. Aortic stenosis associated with aneurysmal dilatation of the ascending aorta. *Acta radiol.*, June, 1955, *43*, 437–444. (From: Roentgen Department, Södersjukhuset, Stockholm, Sweden.)

The authors report a case of extreme dilatation of the ascending aorta occurring in a 32-year-old female who gave a history of slight dyspnea and palpitations since childhood, with sensation of heat in the upper part of the trunk and swelling of the ankles. There was no history of rheumatic fever. An angiocardiogram revealed dilatation of the ascending aorta and arch starting just beyond the aortic ostium and ending 1 cm. distal to the origin of the left subclavian artery. There was no evidence of coarctation. Areas of calcification were seen at the sides of the aortic valves, apparently in association with aortic valvular stenosis.

Fourteen cases in the literature are summarized where congenital aortic stenosis was associated with dilatation of the ascending aorta. Two hypotheses have been presented to explain the ectasia of the aorta. One is the malformative hypothesis, based on alterations in the elastic structure of the media of the dilated aortic wall. It is firmly supported by the observation that this kind of ectasia is often found in cases of arachnodactylia, a condition which is regarded as a mesenchymal dysplasia.

The other hypothesis maintains that poststenotic dilatation may be caused by purely hydromechanical factors. A mass of fluid ejected through a narrow constriction under high velocity strikes a more slowly moving mass of fluid distal to the stenosis. As a result, the high kinetic energy is converted into potential energy or lateral pressure, and the rapid stream is deflected laterally or even completely reversed. The authors conclude that although in some cases the hydromechanical factors predominate in others the dysplasia due to malformation may constitute the basis of the lesion.—*Kriss M. Kerr, M.D.*

STEINBACH, HOWARD L., KEATS, THEODORE E., and SHELINE, GLENN E. The roentgen appearance of the pulmonary veins in heart disease. *Radiology*, Aug., 1955, *65*, 157–168. (From: Department of Radiology, University of California School of Medicine, San Francisco, Calif.)

The degree of vascularization of the lungs has long been used as a diagnostic aid in the roentgen interpretation of acquired and congenital heart disease. After considering the anatomy of the pulmonary veins, the authors discuss the various conditions in which these changes are seen.

An increase in size of these veins due to an increase in the volume of blood flowing through the lungs is seen in the presence of intracardiac shunts in which the blood flow is from the left side to the right side of the heart. This is also seen in cases of patent ductus arteriosus and aortic pulmonary window. The degree of the shunt determines the size of the vessels.

A decrease in size of the pulmonary veins has been demonstrated in patients with pulmonic stenosis, tetralogy of Fallot, tricuspid atresia, and truncus arteriosus. Poststenotic dilatation of the pulmonary artery, which is frequently associated with pulmonic valvular or infundibular stenosis, may give the impression that the flow is increased since the main branches of this artery, and occasionally the hilar vessels, are enlarged. But the small size of the peripheral vessels and particularly of the main pulmonary veins should point to the decreased flow. One proved case of massive pulmonary thrombosis of the main pulmonary artery showed large main pulmonary arteries but exceedingly small veins.

In acquired mitral valvular disease one might expect the pulmonary veins to be enlarged, though actually in most cases they appear normal, or they

may be slightly increased or decreased in size. This has been explained as being due either to a vasoconstriction of the peripheral pulmonary arteries or to organic arterial narrowing which serves to prevent transmission of the high arterial pressure to the pulmonary veins and thus increase their size.

Many diagrams and roentgenographic reproductions are presented to illustrate these various abnormalities.—*Donald N. Dysart, M.D.*

Tori, G., and Cavicchi, L. La flebografia del mediastino per via transossea. (Transosseous mediastinal phlebography.) *Bull. sc. med., Bologna*, 1955, *127*, 1–19. (From: Istituti di Radiologia e del Radio del'Università and Istituto di Patologia Chirurgica dell'Università, Bologna, Italy.)

The venous channels of the mediastinum (i.e., the communicating systems between superior and inferior vena cava) can be visualized by injecting contrast material into the spongious portion of adjacent bone structures. In this series, after adequate local procain anesthesia, 15–20 cc. of urokon 70 per cent were administered in 3–4 seconds. The azygos territory, and the mediastinal veins in general, can be filled by injecting into the spinous processes of T5 through T10, or, easier, into the respective posterior costal segments. For the hemizygos, or its accessory, corresponding portions of the left ribs are approached. The procedure is very similar to sternal puncture (which is employed to fill mammary veins), though with the added problem of possible intolerance to organic iodine compounds.

In this article are described aspects obtained in apparently healthy persons. Mention is also made of a case with opacification of the inferior vena cava (which can be seen in healthy individuals after injecting the lumbar spinous processes) by the intracostal route because of obstruction of the azygos vein by right hilar metastasis from seminoma. The diagnostic potentialities of this method, as well as its contraindications, will have to be determined by future studies.—*E. R. N. Grigg, M.D.*

Greitz, T. Some aspects of the technique in pelvic phlebography. *Acta radiol.*, June, 1955, *43*, 429–436. (From: Roentgen Department, Södersjukhuset, Stockholm, Sweden.)

The author states that satisfactory visualization of the external iliac veins is achieved in eighty per cent of patients with chronic venous insufficiency by routine phlebography following injection of a dorsal vein of the foot. In 73 of those cases in which filling of the pelvic veins was not obtained, various other methods were used in an attempt to evaluate their relative merit. Umbradil 35 per cent was employed, injected as rapidly as possible in 30 ml. amounts.

It was found that injection through a catheter in the popliteal vein resulted in better opacification than direct injection into a superficial vein of the thigh or into pubic varices. Injection of the latter site frequently gave a false interpretation of occlusion of the ipsilateral veins, which later filled when compression was made on the opposite side during administration of the opaque medium.

Catheterization following percutaneous puncture was accomplished in 4 cases via the popliteal and in 8 cases each via the great saphenous and femoral routes. It is stated one of the latter should be used where the former, the method of choice, was unsuccessful or contraindicated. It was not possible to insert a catheter in 16, or 45 per cent, of those cases in which this method was attempted. Of these cases, 13 were characterized as showing obvious changes of a post-thrombotic type.

The author recommends that the patient be examined in prone and supine positions and if appropriate, in the erect position, as well. In a few instances with the patient erect, veins were filled which were not visible in the recumbent position, presumably the result of retrograde flow.—*Thomas B. Efford, M.D.*

Bierman, Howard R., Kelly, Keith H., White, Laurens P., Coblentz, Alexander, and Fisher, Arthur. Transhepatic venous catheterization and venography. *J.A.M.A.*, Aug. 13, 1955, *158*, 1331–1334. (From: Division of Research and Departments of Internal Medicine and Radiology, City of Hope Medical Center, Duarte, Calif.)

For purposes of obtaining multiple blood samples from the portal vein (for investigation of relationship of spleen and liver in the dynamic physiology of the circulating formed elements of the blood), an improved technique for transcutaneous and transhepatic venipuncture and catheterization of the portal and hepatic veins has been evolved. The patient is preferably placed in a semi-Fowler's position and the needle inserted through a point 1 cm. to the right of midline and 1 cm. below xiphoid, to the liver surface. The proper angle of introduction (shown diagrammatically) is confirmed, the patient asked to take a moderately deep breath and hold it, and the needle inserted to 12 cm. The needle is released, and the patient permitted to breathe. The hub of the needle will move in a manner paradoxical to the excursions of liver. A small ureteral catheter can be threaded through a no. 16 or no. 18 needle, and left in place.

Venography should precede and follow the withdrawal of the needle to confirm the location and direction of the tubing in the vessel. For portal venography 20 to 50 cc. of concentrated contrast medium is injected forcibly. Venograms via the

needle afford more contrast than with the small tubing.

One hundred forty-four transhepatic venipunctures were attempted in 73 patients. Portal venous blood was obtained in all but 9 patients. Fourteen patients were catheterized through the portal or hepatic venipuncture needle, and the tubing left in place for two to nineteen days without sequelae. Portal venous blood clots so rapidly that heparin sodium in isotonic sodium chloride should be employed to maintain the patency of needle or catheter.

Since most of the patients studied had widespread neoplastic disease, it was possible to follow most of them until their death. Postmortem examinations were obtained in 55 of the 62 patients who died. Arterial blood was aspirated in 2 cases, intestinal contents in 3 cases, in 1 case the gallbladder was visualized by direct puncture, and in 1 case the cystic duct was catheterized, but in all of these the needle was withdrawn without sequelae. There were no serious complications attributable to the procedure. Evidence of bleeding after venipuncture was found in 3 cases at postmortem examination, but in no case was death attributed to the bleeding.

In the course of these experiments observations on pressures and chemistry of portal blood were made.—*Lois Cowan Collins, M.D.*

KINMONTH, J. B., HARPER, R. A. KEMP, and TAYLOR, G. W. Lymphangiography by radiological methods. *J. Fac. Radiologists*, April, 1955, *6*, 217–223. (Address: Dr. Kinmonth, St. Thomas's Hospital, S. E.1, London, England.)

Roentgenological delineation of the lymph trunks by use of a colored dye, "patent blue," injected subcutaneously to make them visible clinically and then by injection of a radiopaque solution injected directly into the lymph trunks has been described previously by the various authors of this article. The present publication deals with the technical details of the method.

For lymphangiography of the lower limb, 2 cc. of 1 per cent aqueous solution of "patent blue," sterilized by autoclaving, is injected subcutaneously into the interdigital webs of the toes, 1/2 cc. into each, followed by massage over the sites of injection and movement of the toe and ankle joints. Then, with the table in Trendelenburg position a transverse incision is made on the dorsum of the foot 1½ inches proximal to the toes. Using a number 18 hypodermic needle, 70 per cent diodone is injected. Usually 5 to 6 cc. of solution is sufficient to outline the lymph trunks. The injection must be stopped if there is any sign of extravasation into the tissues. The shadow of the lymph trunks remains best for about 5 minutes. Consequently, as soon as injection is complete, the patient is placed in horizontal position and roentgenograms are made. In the normal lymphangiogram the trunks remain of the same diameter but bifurcate as they pass upward, so that their number increases. In a patient with lymphatic edema and reflux of intestinal chyle into the leg, the vessels were markedly varicose, and clinically the chylous reflux was shown by the appearance of white blisters on the involved leg. In a case of multiple congenital arteriovenous fistulae, overgrowth of the bones and lymph edema of the lower leg and ankle were present. The lymph vessels were beaded and tortuous in the lower leg, but they passed upward to join trunks of normal appearance in the thigh. In familial lymph edema (Milroy's disease), the lymph trunks were scarce and did not branch and multiply in the normal manner, but remained as a single thread.

In pelvic lymphagiography, 2.5 cc. of 11 per cent "patent blue" is injected into the foot as for lymphangiography of the lower extremity. The site of injection is massaged, and then ankle, knee and hip joints are flexed fully and repeatedly for 5 to 10 minutes. With the table in Trendelenburg position, and with the patient under full surgical anesthesia to relax the abdominal muscles, and to facilitate the proximal flow of opaque contrast medium, a transverse incision is made below and lateral to the pubic spine until blue dye-filled lymph trunks are found passing between the inguinal lymph nodes and the lower end of the femoral canal. A large trunk is freed on its anterior aspect for about ½ inch. Then, using a number 18 hypodermic needle, a total of about 8 cc. of diodone is injected. Then, with the table horizontal, roentgenograms are made. The normal pattern is a group of vessels looking much like a mass of spaghetti segments ready for ingestion. In idiopathic lymph edema of the scrotum, the contrast medium spreads out into a wide pelvic network. In the patient with lymph edema and chylous reflux into the leg, very large chyle-filled vessels were found in the groin and the lymph trunks were tortuous, numerous and large.

In *lymphangiography of the upper extremity* the attainment of a bloodless or nearly bloodless field may be accomplished by the use of a tourniquet, although this may partially obscure the view of the lymph trunks. "Patent blue," using 1.5 to 2 cc. in divided doses, is injected into the interdigital webs, the sites of injection are massaged, and then the joints of the upper extremity are passively and fully flexed several times. An Esmarch rubber bandage is used to secure a bloodless field and this is maintained by a pneumatic cuff on the upper arm. A transverse incision is made just below and slightly medial to the antecubital skin fold, and 1 to 2 cc. of 70 per cent diodone injected. Normally the lymph trunks of the arm are smaller than those of the leg. In a patient with postmastectomy lymph edema the vessels are not wider than normal, but some of them are tortuous and there is abnormal lateral and retrograde flow of the contrast medium. In a patient with blocking of the axilla by a large rapidly

growing tumor of fibrous and angiomatous structure, the injected vessel was not dilated, but it turned sharply at right angles when the obstruction was encountered, continuing its course in collateral vessels. The absence of dilatation of lymphatic trunks in acquired lymphatic obstruction suggests: (1) that mechanical obstruction does not cause lymphatic dilatation, and (2) that the very dilated vessels in cases of congenital and idiopathic lymph edema are of developmental origin.

Roentgenological Technique.—The films or cassettes are placed in boxes under the sterile towels below the part to be examined prior to the injection. Two films may be placed end to end to demonstrate the whole length of a limb. Serial films such as are required in arteriography are usually not necessary. A wedge filter to compensate for the varying thickness of the lower limb is advantageous. Technique used by the authors: Non-screen film, 65 kv., 65 ma., 2 seconds, 48 inches distance; for thicker parts: Cassette and grid, 80 kv., 45–50 ma., 1.5 seconds, 48 inches distance.—*Samuel G. Henderson, M.D.*

Hultborn, K. A., Larsson, L.-G., and Ragnhult, I. The lymph drainage from the breast to the axillary and parasternal lymph nodes, studied with the aid of colloidal Au^{198}. *Acta radiol.*, Jan., 1955, *43*, 52–64. (From: Radiumhemmet, Department of Surgery, Institute of Radiophysics and Institute of Radiopathology, Karolinska Sjukhuset, Stockholm, Sweden.)

The anatomy of the lymphatic drainage of the breast and the clinical incidence of axillary, parasternal (internal mammary), and both axillary and parasternal lymph node metastases are discussed quite fully in the opening paragraphs of this paper. A fairly high incidence of parasternal metastases —as much as 36 per cent—has been observed clinically, even in tumors of the outer quadrants.

The authors chose to inject radioactive colloidal gold into different sections of the breast in patients in whom radical mastectomies were to be performed. The dissections included the axillary lymph nodes in 40 patients, the parasternal lymph nodes in 14 patients and the supraclavicular lymph nodes in 2 patients. In vivo measurements of the lymph drainage areas were made with a scintillation counter and in vitro counts and autoradiographs were also made.

No contralateral uptake was found in any case. Regardless of the site of injection in the breast, some lymph nodes showed an uptake. In all 14 cases in which the parasternal lymph nodes were dissected, an uptake was demonstrated in those lymph nodes. It is shown that lymph drainage occurs to the axillary and parasternal lymph nodes from any segment of the breast. However, the quantitative uptake in the axillary lymph nodes was greater than in the parasternal lymph nodes. This study reemphasizes the importance of the parasternal lymph nodes in the management of cancer of the breast.—*George A. Roberts, M.D.*

General

Rosen, Bernard. Ornithosis as an occupational hazard. *Radiology*, Sept., 1955, *65*, 373–377. (Address: P. O. Box 961, Corsicana, Texas.)

Forty-eight of a total of 120 employees of a poultry processing plant developed ornithosis within a period of five days. Thirty-four of these patients were hospitalized and fifteen of this group had roentgenographic examination of the chest. The carriers in this epidemic were turkeys, and only employees working in either the picking or eviscerating section of the plant were infected.

The causative organism of ornithosis is a virus, Miyagawanella psittaci. Symptoms include severe headache, muscle pains confined mostly to the neck, shoulder, and lumbar region, gastrointestinal tenesmus without diarrhea, profuse sweating with chills, pharyngitis, and occasionally impairment of the sensorium. Severe cough and expectoration are noted forty-eight to seventy-two hours after the onset. Physical findings include fever, sweating, restlessness, hyperemia of the pharynx, and rales and decreased breath sounds over the involved lung segments.

The only laboratory examination of value in establishing the diagnosis is a complement-fixation test utilizing lymphogranuloma venereum antigen with a three- to fourfold rise in titer being diagnostic.

Roentgenographic findings in ten of the fifteen patients examined were focal circumscribed areas of pneumonic consolidation involving one or more areas and not confined to any particular lobe or segment of the lung. In the other five patients interstitial infiltration was the primary finding.

Treatment consisted of antibiotics plus supportive measures, with tetracycline appearing to be the most effective antibiotic.—*Harold C. Hamilton, M.D.*

Katz, Isadore, and Steiner, Karl. Ehlers-Danlos syndrome with ectopic bone formation. *Radiology*, Sept., 1955, *65*, 352–360. (From Departments of Radiology and Medicine, Veterans Administration Hospital, Brooklyn, N. Y.)

The classical findings of the Ehlers-Danlos syndrome are hyperelasticity of the skin, hypermobility of the joints, and fragility and friability of the skin and its blood vessels. Small, cystlike, movable subcutaneous nodules are often observed. Perhaps the pathognomonic roentgenologic finding is the presence of disseminated calcified subcutaneous

nodules of distinctive appearance which are confined to the extremities, being most numerous in the anteromedial area of the lower two-thirds of the legs and presenting a fairly symmetrical appearance in the extremities. These calcified nodules are almost invariably ovoid in shape, range in size from 4 to 8 mm., and show a homogeneously dense calcific structure bordered by a sharply defined peripheral zone of more dense calcification.

A case of a 38-year-old white man with the classical findings of the Ehlers-Danlos syndrome and an additional finding of large masses of mature ectopic bone in the hip muscles bilaterally is presented. It is believed that these masses of ectopic bone are a hitherto unobserved feature of the syndrome.—*Harold C. Hamilton, M.D.*

Grove, James H. Kaposi's disease; report of an unusual case. *Radiology*, Aug., 1955, *65*, 236–240. (From: Mt. Sinai Hospital, Cleveland, Ohio.)

Kaposi's disease, now more properly designed as "idiopathic multiple hemorrhagic sarcoma," is best known for its cutaneous manifestations, varying from soft vascular to firm pigmented nodules or plaques, found usually in the lower extremities. Visceral involvement occurs in about 10 per cent of the cases, but usually late in the course. Death usually occurs in five to ten years, but some cases have lived longer. A multicentric origin is thought to be present since cases have been reported where visceral involvement only was present, or visceral involvement preceded the skin nodules, or the skin involvement antedated visceral involvement by many years.

The author reports a case of Kaposi's disease in an American Negro where the primary involvement was thought to be in the stomach and small intestine with the cutaneous nodules being found later. Multiple mucosal and submucosal tumors, some of which were superficially ulcerated and had produced massive hemorrhage, were found in the stomach. These lesions were histologically similar to the skin lesions. A gastric resection stopped this patient's symptoms of hematemesis.—*Donald N. Dysart, M.D.*

RADIATION THERAPY

Wyard, S. J., Nightingale, A., and Austin, I. G. Radiation hazards in the use of thorium X for skin therapy. *Brit. J. Radiol.*, May, 1955, *28*, 274–278. (From: Physics Department, Guy's Hospital Medical School, London, S.E.1, England.)

Thorium X as an alpha-ray emitter with a short half-life of 3.64 days has been used in many dermatological departments for the treatment of a wide variety of skin conditions, especially in Europe. In many instances the usual precautions taken with radioactive materials have been relaxed, assuming the short half life and the short range of the alpha particles rendered the material relatively safe. The authors have therefore made a scientific study of the hazards to both personnel and patients in the use of thorium X.

The usual dose given is 1,000 e.s.u. which is equivalent to 72 ± 6 micrograms of radium with standard filtration, or a gamma ray dose-rate of .55 $\pm$.07 r/h. at 1 cm. distance, assuming the thorium X is in equilibrium with its decay products. The immediate danger is that of inhaling the initial decay product, thoron gas (half-life 54.5 seconds). The authors found that by using a well ventilated room with open windows and exhaust fans, and by keeping the thorium and its applicator in well stoppered bottles between applications, the maximum permissible thoron concentration for continuous weekly exposure of 35×10^{-10} curie-hours per liter is rarely exceeded. They also state that lead containers or protective lead barriers should be used to reduce the danger from beta and gamma rays, and rubber gloves should be worn by the therapist to avoid skin contamination.

The hazards to the patient appeared much more significant. It was found that one standard application of thorium X, could equal six months exposure to the maximum permissible level of 10^{-10} c/l. of thoron gas. The gamma dose to the gonads only appeared to be important when the scrotum or immediate area was painted. It was also found that appreciable doses of radiation may be received by the blood, thyroid, bones, and kidneys following local dermal applications. The quantity of long lived radioactive isotopes would be well below the maximum permissible level, however.—*Arch H. Hall, M.D.*

White, Thomas Taylor. Carcinoma of the breast in the pregnant and the nursing patient; review of 1,375 cases. *Am. J. Obst. & Gynec.*, June, 1955, *69*, 1277–1286. (From: Department of Surgery, University of Washington School of Medicine, Seattle, Wash.)

A group of 1,375 cases of carcinoma of the breast complicated by pregnancy was collected from 144 articles published in the world's literature and from personal communications.

Carcinoma of the breast occurs in about 3 out of 10,000 pregnancies and about 3 out of 100 breast carcinomas were complicated by pregnancy. The gross 5 year survival rate (59 per cent) and 10 year survival rate (47 per cent) of patients treated for mammary carcinoma who later became pregnant is comparable to the survival rate of those with breast carcinoma who were not pregnant. Patients without metastases survived 10 years at a rate of 21.5 per

cent, whereas the summation of reports of 10 year survivals for all cases of carcinoma of the breast and pregnancy gave only 8.6 per cent. Patients with metastases treated during pregnancy or lactation had a 5 to 20 times poorer prognosis than those without metastases. The prognosis of patients treated during the 2nd and 3rd trimesters of pregnancy was less favorable than those treated during the 1st trimester or lactation. No benefit was demonstrated in 108 cases in whom abortion occurred.

The conclusion is reached that the average patient probably should be allowed to have pregnancies subsequent to treatment for carcinoma of the breast, as the survival rate does not appear to be appreciably altered by pregnancy.

There was an average of 3 months' delay between the doctor's examination and treatment. Biopsy should be taken of the walls of inflammatory lesions at the time of incision and drainage. Masses should be biopsied promptly if they persist.—*Charles W. Cooley, M.D.*

NEWBERY, G. R., and BEWLEY, D. K. The performance of the medical research council 8 MeV linear accelerator. *Brit. J. Radiol.*, May, 1955, *28*, 241–251. (From: Radiotherapeutic Research Unit of the Medical Research Council, and Physics Department, Hammersmith Hospital, London, W.12, England.)

The first 8 mev. travelling wave linear electron accelerator for clinical use had been in operation for fifteen months at the time this article was submitted. During this time four hundred patients were treated, with only one major operational fault preventing the treatment of several patients on one day. Several minor mechanical improvements have been necessary to reduce the number of after-hour repairs. For a first machine, the operation has been very satisfactory. It is operated at 350 pulses/second with an output of 100 rads/minute at 2 cm. deep in a water phantom with its surface at 1 meter from the target. The head of the machine can rotate to direct the beam from fifteen degrees beyond the vertical to fifteen degrees above the horizontal, providing a utilisable therapeutic generator. Front and back pointers, and light beam localisation apparatus have been attached for precision therapy.

The article contains a floor plan of the installation with protection measurements, a description of the beam flattening differential filter, and output and isodose data.—*R. Kenneth Loeffler, M.D.*

KUTZ, EUGENE R. The radiotherapeutic test: an unreliable diagnostic procedure in intrathoracic mass lesions. *Radiology*, Sept., 1955, *65*, 378–383. (From: Allegheny General Hospital, Pittsburgh, Penna.)

The author defines the radiotherapeutic test as a diagnostic procedure in which the histologic family to which a lesion belongs is determined by its response to a measured quantity of roentgen rays. In the past this test has been of great value since thoracotomy was not used as a diagnostic procedure because of high morbidity and mortality rate. In recent years, however, thoracotomy has not been considered dangerous and is used frequently in the diagnosis of chest pathology.

It is stated that at the present time there is seldom any reason to recommend a radiotherapeutic test preoperatively. If the diagnosis cannot be established by any of the conventional methods of diagnosis, thoracotomy is the next step unless contraindicated. Reasons given for avoiding the therapeutic test are:

1. When it is employed to make a diagnosis, operation may be delayed long enough to cause an operable lesion to become inoperable.

2. Because of the apparent variability in the response of lesions of similar histology to similar doses of roentgen rays, the test is frequently inaccurate.

Treatment of intrathoracic mass lesions of undetermined histology is not condemned, since there will always be patients on whom a diagnosis cannot be made by conventional methods who will not submit to diagnostic thoracotomy, patients whose general condition contraindicates thoracotomy, and patients with obviously advanced disease for which palliation is all that is possible. Under such circumstances, however, one should administer radiation with treatment as the primary objective, rather than diagnosis.

Six cases are presented. These cases illustrate the variability of tumor response to irradiation, and the difficulties in the determination of tumor type by this means.—*A. Ralph Watson, M.D.*

NOTTER, G. Das maligne epibulbäre Melanom. Bericht über 35 Patienten. (Malignant epibulbar melanoma; a report of 35 patients). *Strahlentherapie*, April, 1955, *96*, 517–537. (From: General Division of Radiumhemmet, Stockholm, Sweden.)

This report deals with malignant melanosarcomas, or carcinomas (depending on which hypothesis of histopathogenesis one supports), of the corneal limbus, the bulbar conjunctiva, the palpebral conjunctiva, or the bulbar and palpebral conjunctiva. The benign tumors pigmented with melanin are called naevi pigmentosi rather than melanomas.

From 1921–1953, 35 patients with malignant, epibulbar melanomas were treated at the Radiumhemmet in Stockholm. Of these: 14 (40 per cent) died of metastases, 20 (57.2 per cent) are free of tumor; 14 (40 per cent) are alive and symptom-free; 1 is alive with residual tumor nine years after treat-

ment; 6 died of intercurrent causes; 7 had local residuals at the beginning of treatment; 5 had regional metastases; 3 treated only by irradiation, were symptom-free five, nine and eleven years after treatment; 15 (43 per cent) had five-year "cures"; 10 (28 per cent) had ten-year "cures."

In the surgical treatment, enucleation and exenteration are preferred to local excision. Local coagulation is avoided.

Treatment by irradiation included weakly filtered (0.2 mm. Ni) radium in porcelain applicators with a surface intensity of about 4,700 r per hour, up to 84 per cent beta-rays. Better suited were Sr^{90} and soft roentgen rays (half value layer 0.055 mm. Al). The pure beta-emitter permits short treatment times because of its high intensity, and avoids injury to the lens. Conventional roentgen radiation, on the contrary, produced cataracts. To avoid residuals, radiation therapy should be carried on to disappearance of the tumor. The author recommends that, in those patients being treated by radiation alone, biopsy be performed when half of the radiation has been administered.

In addition to the above 35 patients, 13 patients were treated with radiation therapy only, without histologic study of the tumor. Of these: 1 died of metastases; 2 died of intercurrent disease; 1 is alive after twenty-five years with local residuals of tumor; and 9 are alive and symptom-free.

No prepubertal patients with epibulbar melanomas are reported in the literature; this report also includes none. However, 2 of the 13 patients whose tumors were not biopsied were younger than ten years. They are symptom-free thirty-one and twenty-five years after radiation therapy.

Indications for radiation therapy are: all discrete, small, flat tumors in the region of the palpebral and bulbar conjuctiva if (1) surgical treatment necessitates loss of the eye; (2) surgical treatment is refused; or (3) the tumor would not be totally excised.

Among the technical details of treatment methods, the author cites this "standard" procedure for radiation therapy of a thin tumor: 5–10 treatments of 2,000 beta-r in four to nine days to one or two fields with a strontium applicator (7.8 mm. in diameter), or similar dosage with soft roentgen rays. Biopsy should be performed after the first three doses of 2,000 r. If the tumor has not responded within four months, additional radiation with 6,000–10,000 beta-r is given. If this is without success, the tumor must be excised.

After allowing for the relatively earlier diagnosis and the more circumscribed field of growth in melanomas of the eye as compared with those of the skin, the author feels that differences in malignant potential are apparent more than real.

Anyone who has to deal with an epibulbar melanoma would do well to consult this article in the original—*Henry G. Moehring, M.D.*

RADIOISOTOPES

Turner, John W. Radioactive isotopes in a community hospital. *New England J. Med.*, May 12, 1955, *252*, 806–809. (Address: Chief, Department of Radiology, Westfield State Sanatorium, Westfield, Mass.)

After twenty years of research in physical aspects, animal experimentation; and, in the past fifteen years, increasing application of radioactive isotopes for human needs there is now a justification for use of an isotope such as I^{131} in small general hospitals detached from university centers. The selection of an isotope for use at the community hospital level should involve two principal considerations: The particular isotope should improve the accuracy of diagnosis for the effectiveness of therapy in the conditions to be dealt with as compared to older or more readily available modalities; and, the cost to the patient should be less than or equivalent to existing fees for drugs, hospital services and professional services to accomplish the same result. To some extent these two criteria may be mutually compensatory.

Concern has been expressed about the carcinogenic effect of I^{131} especially from the larger doses as for therapy. After fifteen years no cause-and-effect relation has been observed. It is suggested in this article that large quantities of ionizing radiation began striking non-malignant thyroid tissue much longer than fifteen years ago in roentgen and radium therapy of hyperthyroidism and treatment of cancers in adjacent tissues such as the larynx and cervical lymph nodes without any verified thyroid cancer production.

Radon implants of the past several decades constitute a rather analogous example of long term intense focal beta and gamma radiation effect with no appreciable carcinogenesis in benign tissues such as hemangioma. The fetal thyroid has been found to pick up I^{131} by the fourteenth week of pregnancy and the nursing infant to concentrate I^{131} from the mother's milk. On the other hand, normal pregnancy and subsequent normal growth and development of the resulting child have been reported after a dosage of 95 millicuries of I^{131} for cancer of the thyroid. This is about twenty times a possible therapeutic dose for Graves' disease.

Several developments of recent years favor the initiation and operation of isotope programs within small general hospitals:

1. The distribution program of AEC initiated in 1946.
2. The availability of precalibrated diagnostic and therapeutic isotope units delivered by air transport facilities from commercial sources with less need for hot-laboratory facilities locally.
3. The availability of part-time consultant medical nuclear physicists and of isotope training courses for physicians.

4. The availability of reasonably priced detection and measurement equipment.
5. Most important of all, the accumulation of well-documented clinical experience, especially in I^{131} usage.—*Author's Abstract.*

Demorest, Howard L., and Sandhaus, Sol. An evaluation of the gland depth error in measuring the thyroid uptake of radioiodine. *Radiology*, May, 1955, *64*, 701–703. (From: Radioisotope Unit, Veterans Administration Hospital, Minneapolis, Minn.)

The in vivo determination of radioiodine uptake by the thyroid gland is now a standard procedure for the diagnosis of thyroid function, but there still is some question as to the method of performing the uptake study which will give the greatest accuracy.

The authors made a study to evaluate the relative accuracy of the calculated depth method and the average depth method. For this purpose a neck phantom was constructed of thin-wall lucite tubing. On the basis of a study of thyroid outlines obtained with a scanning scintillation counter, it was determined that the maximum width of the thyroid gland projected into the plane of the counter face was 9 cm. Within this width, a dose of I^{131}, divided equally between two 5 cc. vials, was placed in the phantom, the vials being so positioned as to simulate thyroid lobes at known distances varying from 1.4 to 6.6 cm. behind the outer surface of the phantoms. The depth of the vials was calculated from measurements made at three distances.

It was evident from the results that the calculated depth method and the average depth method of carrying out uptake measurements yield results of equivalent validity over the possible range of average gland depths.—*A. W. Sommer, M.D.*

Kramer, S., Concannon, J. P., and Clark, G. M. Thyroid carcinoma; a report on the diagnostic and therapeutic use of radioiodine. *Brit. J. Radiol.*, June, 1955, *28*, 307–313. (Address: S. Kramer, Radiotherapy Department, St. Boniface Hospital, St. Boniface, Manitoba, Canada.)

Forty-eight patients with carcinoma of the thyroid have been investigated at the Royal Marsden Hospital, from the aspect of radioiodine concentrating facility of the tumor. Thirty-five of these failed to demonstrate iodine uptake by the tumor. In six of this latter group, thyroid ablation was performed in an attempt to stimulate tumor uptake of radioiodine, without success. This group of carcinomas consisted mainly of papillary adenocarcinomas and anaplastic carcinomas, but also contained other types including several well-differentiated adenocarcinomas.

Thirteen tumors showed sufficient iodine concentration to warrant therapy. Four of these were adenocarcinomas with colloid formation, two each of papillary and of Hürtle cell carcinoma, and five unspecified. Histology alone should not act as a deterrent to performing uptake studies after ablation of the thyroid to determine suitability for radioiodine therapy. Three of four with local disease only and two of eight with distant disease, responded well. Most of the patients had advanced disease when they were first seen, those not responding surviving for only one to four months.

The authors also give two case histories, one quite dramatic; and briefly describe an automatic scanner with examples of its clinical use for the detection and evaluation of iodine-concentrating metastases.—*R. Kenneth Loeffler, M.D.*

Balls, Kent F., Chamberlin, Richard H., Rose, Edward, Gorson, Robert O., and Blount, Henry C., Jr. The treatment of thyrotoxicosis with radioiodine. *Radiology*, June, 1955, *64*, 858–866. (From: Department of Radiology and Endocrine Section of the Medical Clinic, Hospital of the University of Pennsylvania, Philadelphia, Penna.)

The results of treatment with radioiodine are reported in 180 thyrotoxic patients who were followed for intervals varying from one to five years. Thyrotoxicosis was relieved after a single treatment in about 80 per cent, and after one or more treatments in 97.2 per cent of these patients.

The authors have not been satisfied with the various formulae used to determine the dose of I^{131} which offers the maximal prospect of producing a permanent euthyroid state with minimal risk of residual permanent hypothyroidism. Their dose is based on a rough estimate of the size of the gland and the clinical and tracer evidence of the severity of the thyrotoxicosis. The initial dose was usually not less than 6 millicuries or more than 10 millicuries of I^{131}. Thirty-nine of the 180 patients (21.6 per cent) received two or more treatment doses. The average beta dose was calculated using the following formula: $D_e = 73.8\bar{E}TC_0$ rads where $\bar{E}$ is the effective average beta particle energy in mev.; T is the effective half life in days; C_0 is the initial average concentration in microcuries per gram.

Initial single doses of 5,000 to 10,000 rads were given to 92 of 176 patients (52 per cent); 41 patients 23 per cent) received initial single doses between 10,000 to 15,000 rads. There was considerable variation in response with rather poor correlation between the therapeutic results and the administered dose in millicuries and the calculated dose in rads.

The incidence of protracted post-therapeutic hypothyroidism was 18.3 per cent.—*Arno W. Sommer, M.D.*

Cunningham, R. M., Hilton, Gwen, and Pochin, E. E. Radioiodine uptake in thyroid carcinomata. *Brit. J. Radiol.*, May, 1955, *28*,

252–256. (From: Department of Clinical Research, University College Hospital Medical School, London, W.C.1, England.)

Several studies on radioiodine turnover by carcinomatous thyroid tissue are described. In one superficial metastasis accessible for careful measurement, the rate of clearance of iodine from the plasma per gram was shown to be about one-tenth that of the normal thyroid, or about one-hundredth that of hyperfunctioning tissue. The mean biological half-period of retention of iodine by several metastases studied was about 3.5 days. This rapid turnover of iodine by tumor tissue results in a beta dose of only about 30 per cent of the maximum which would be delivered if the accumulated radioiodine were retained permanently. The authors offer evidence that this rapid turnover is not due to the destruction of tumor tissue by the delivered radiation, nor to the excessive output of thyrotropin which occurs as a result of the patient's hypothyroid status. A possible explanation is, that while tumor cells can concentrate iodine, they cannot retain it in the absence of well-formed follicles. It may be that more carcinomas of the thyroid concentrate iodine than is generally noted, but that this uptake is not clearly demonstrated because of the rapid release.—*R. Kenneth Loeffler, M.D.*

BISHOPRIC, GEORGE A., GARRETT, NORMAN H., and NICHOLSON, WILLIAM M. The thyroidal uptake of radioactive iodine as modified by an iodine-restricted diet. *J. Clin. Endocrinol. & Metabol.*, May, 1955, *15*, 592–597. (From: Department of Medicine, Duke University School of Medicine and Duke Hospital, Durham, N. C.)

Twenty patients who were receiving the Kempner rice diet were studied with reference to thyroidal 24 hour uptake of I^{131}. This group was compared with a control group of 125 euthyroid patients. Fifty per cent of the rice diet group had uptakes higher than the authors' normal 24 hour uptake range of 15 per cent to 45 per cent. The highest was 92 per cent.

The basic rice diet employed provides 8 to 10 micrograms of iodine per day and the modified one supplies 20 to 25 micrograms per day. The basic diet is low compared to the minimal daily requirements of iodine estimated as low as 14 micrograms per day by some and as high as 40 micrograms per day by others. A gram of iodized table salt has 160 micrograms of iodine. Two patients who admitted eating fish showed opposite uptake trends. The salt water fish eater had a normal uptake and the fresh water fish eater had a 92 per cent uptake. Salt water fish have a relatively high iodine content and fresh water fish do not show such a striking variation of iodine content.

After three months on a rice diet there is likely to be a heightened thyroid uptake but no thyroid gland enlargement. This increased uptake is attributed to iodine restriction coincident with diet.—*John W. Turner, M.D.*

MILLER, EARL R., and SCOFIELD, NORMAN E. Studies with radioiodine. IV. Collimating cones for crystal counters. *Radiology*, July, 1955, *65*, 96–107. (From: Radiological Laboratory, Department of Radiology, University of California School of Medicine, San Francisco, Calif.)

The authors designed four multichannel and two single-channel collimators for scintillation counters. These were tested for sensitivity and degree of collimation by studying the response of the counter, to which they were attached, at various distances from a point source of I^{131}.

Uncollimated scintillation counters have a high sensitivity to gamma rays but have poor "localizing ability" at any appreciable distance. It is possible, by the use of a collimating cone, to gain a higher order of "localizing ability" at the expense of sensitivity. Single-channel collimators with small apertures have the disadvantage of using only a small portion of the crystal and therefore are of low sensitivity. Better "localizing ability" and greater sensitivity can be achieved by the use of multichannel collimators.

A scanning device is described for moving the counter and collimator over the point source at a constant rate of speed while the response of the counter is recorded. A bell-shaped curve is plotted by the recorder for each scan at each distance between the source and the counter. The sensitivity of each of the counters is given by the height of the scan curve. The width of the curve at half its height gives a measure of the degree of collimation.

It was found that when the face of the collimator was less than 7 cm. from the source, one of the single-channel collimators had the highest degree of merit. At all greater distances a multichannel collimator called the "honey cone" collimator gave the best results.—*A. W. Sommer, M.D.*

KERR, H. DABNEY, FLOCKS, R. H., ELKINS. H. B., CULP, DAVID, and EVANS, T. C, Follow-up study of one hundred cases of carcinoma of the prostate treated with radioactive gold. *Radiology*, May, 1955, *64*, 637–641. (From: Departments of Radiology, Urology, and Radiation Research Laboratory of the College of Medicine, State University of Iowa, Iowa City, Iowa.)

The authors present a series of 100 cases treated by combined interstitial injection of radioactive gold and surgery. All the patients were observed for a period of at least two years, and some for as long as

thirty-nine months. An additional group of 52 cases has been under observation for a period of one to two years. In all the reported cases, retropubic exploration was done, with microscopic proof of the neoplasm and determination of the gross extent of the lesion. Any grossly involved lymph nodes were removed and the radioactive gold was injected into the prostate through a retropubic incision.

Their technic is as follows: The mass of the primary lesion is estimated and is injected with radioactive gold in the amount, approximately of 2 millicuries per gram of tissue. About 10 to 12 cc. of material is used for the average neoplasm, with a dose of 80 to 125 millicuries. They regard 175 millicuries as a maximum dose. Follow-up physical examinations are made at frequent intervals and, if suspicious nodules are palpated per rectum, these are injected perineally with more radioactive gold.

Among the first 50 patients, there were 7 who had rectal ulceration. This complication did not occur in the last 102 cases treated. This indicates that rectal complications can be eliminated by careful attention to details. Calculus formation in the sloughing prostatic tissue occurred in 21 of the 152 cases.

Their experience indicates that it is practically impossible to sterilize any except the smallest of neoplasms with radioactive material alone. They have, therefore, resorted to surgical removal of the tumor before or after interstitial injection of the Au^{198}. Time and method of surgical removal and of additional treatment were individualized for each patient.

Of the first 100 patients followed from 24 to 39 months, 46 were alive, 18 with disease and 28 without disease; 54 were dead. At least 13 died of causes other than carcinoma.—*A. W. Sommer, M.D.*

Einhorn, J., Larsson, L. G., and Ragnhult, Inger. Radioactive yttrium (Y^{90}) as a possible adjunct in the treatment of papillomatosis of the urinary bladder. *Acta radiol.*, April, 1955, *43*, 298–304. (From: Radiumhemmet and The Institute of Radiophysics, Karolinska Sjukhuset, Stockholm, Sweden.)

The authors investigated Y^{90} with regard to possible use in the bladder in the treatment of papillomatous villi. The isotope has a half-life of 61 hours, a hard β-radiation with a maximal energy of 2.23 mev., and a mean energy of 0.9 mev. Solutions of the radioactive salt $Y^{90}Cl_3$ formed, in the presence of urine, a precipitate of yttrium phosphate which dissolved only in strongly acid mixtures ($pH < 2$). This precipitation was prevented by the use of a chelating agent, either Ca-di Na EDTA, or Na citrate.

After instillation of the radioactive yttrium through catheters into the bladders of four patients for periods of 1.5 to 2.5 hours, approximately 100 per cent of the amounts of Y^{90} injected was recovered from three patients when the bladder was emptied and washed out; in the fourth patient some leakage occurred around the catheter and only about 80 per cent of the Y^{90} was recovered. Blood samples and 24-hour urine specimens showed detectable but extremely low measures of radioactive material, so that absorption by the bladder apparently was negligible.—*Arthur S. Tucker, M.D.*

Miller, Earl R., Lindsay, Stuart, and Dailey, Morris E. Studies with radioiodine. V. Validity of histologic determination of I^{131} radiation changes in the thyroid gland. *Radiology*, Sept., 1955, *65*, 384–393. (From: Departments of Radiology, Pathology, and Medicine, University of California School of Medicine, San Francisco, Calif.)

This article presents the results of an investigation intended to detect changes in thyroid tissue due to radiation from I^{131} and to distinguish them from changes attributable to other causes. The following phases of the problem are considered:

1. Test-retest studies in which the pathologist attempted to distinguish irradiated from nonirradiated tissues by their histologic appearance; 2. An analysis of the consistency and reliability of these interpretations; 3. A careful histologic study and description of the tissues; and 4. The differentiation of those histologic characteristics which were attributed to irradiation from those due to other causes.

Histologic sections from the thyroid glands of 19 unirradiated patients with various thyroid diseases were thoroughly mixed with sections from tissue from 20 patients irradiated with I^{131}. Of these latter patients, all but one had toxic diffuse goiter. The pathologist recognized with considerable certainty the tissues of those patients who had not been irradiated (57 of 60 negative readings in 19 cases), and the tissues of those patients who had received more than 15 mc. of I^{131} orally (15 of 16 positive readings in 4 cases). There was less certainty of recognition of the effects of radiations from I^{131} in the tissues from patients who had received from 7 to 10 mc. of I^{131}. There was considerable certainty of the absence of recognizable effect in the tissues from patients who had received less than 7 mc. of I^{131}.

The tissue obtained twenty-four days after the largest dose of I^{131} showed acute epithelial necrosis associated with subacute inflammation. Tissues obtained a considerable length of time after the administration of smaller doses of I^{131} were characterized by follicular atrophy and extensive perifollicular and interlobar fibrosis. A description is given of the histologic characteristics in the three tissues which distinguish the effects of irradiation from those due to other causes.—*A. W. Sommer, M.D.*

HORST, W., and GADERMANN, E. Ergebnisse der Strahlenresektion bzw. Elimination der Schilddrüse mit Radiojod bei fortgeschrittenen Herzerkrankungen. (Results in advanced cardiac disease from radiation resection or elimination of the thyroid by the use of radioactive iodine.) *Strahlentherapie*, May, 1955, *97*, 87–93. (From: Strahleninstitut des Universitätskrankenhauses Hamburg-Eppendorf, I. Medizinische Univ.-Klinik und II. Medizinische Univ.-Klinik, Hamburg-Eppendorf, Germany.)

Published reports of the results of surgical removal of the thyroid from patients with advanced cardiac insufficiency of various causes, show a beneficial effect on two-thirds of the patients, but an operative mortality of 10 per cent.

Thyroid function can be suppressed or abolished by radioactive iodine without immediate risk. The authors administered 20,000 rep per gram of thyroid tissue twice with an interval of seven to fourteen days; this treatment was repeated every two months unless the iodine uptake had fallen to hypothyroid levels, or clinical indications for depressing thyroid function no longer existed—until the desired degree of hypothyroidism was attained. The aim of treatment was to individualize dosage so that the hypothyroidism was no greater than necessary, but, at the same time, the cardiac symptoms were maintained at a minimum. Other treatment of the cardiac disease was carried on just as if radioactive iodine were not being administered.

Since the patients being treated have a short life expectancy, considerations of the risks of radioactive iodine therapy (faster progression of arteriosclerosis as a result of the altered blood lipid spectrum; carcinogenic activity of I^{131}) are of no significance. Whether this therapy prolongs life cannot be evaluated before five to ten years of observation of treated patients has been accomplished.

Of 19 patients, 13 were benefited and 6 were unaffected.—*Henry G. Moehring, M.D.*

LEVENSON, JOSEPH M., JIMENEZ, LOUIS E., SAMET, ELI T., and FRIEDELL, MORRIS T. Evaluation of peripheral circulation with radioactive iodinated serum albumin; a preliminary report. *A.M.A. Arch. Surg.*, Aug., 1955, *71*, 167–170. (From: Hektoen Institute for Medical Research of the Cook County Hospital and Department of Surgery, Stritch School of Medicine, Loyola University, Chicago, Ill.)

There is a considerable literature on the investigation of peripheral blood flow and the response to the treatment of related vascular diseases but, except for arteriography, indirect methods of estimation are used in most techniques. Intravenously injected serum albumin remains within the vascular bed for a satisfactory period without diffusion and when labeled with I^{131} (100–130 microcuries) the activity, measured against the sole of the foot, provides a direct measurement of peripheral circulation.

In the normal, the count rate reaches a plateau about four minutes after injection, the maximum value corresponding to the blood volume passing through the foot. Subsequent lumbar sympathetic block, with accompanying rise in skin temperature, is followed by an increasing count rate, a second plateau showing increased blood flow being obtained after a further five minutes. In the presence of symptomatic arterial insufficiency the plateau occurs at only about half the normal value but, following sympathetic block, the count rate is increased and postsympathectomy uptake curves are within the normal range.—*Raymond Quick, B. S.*

KRISS, JOSEPH P., BIERMAN, HOWARD R., THOMAS, SYDNEY F., and NEWELL, ROBERT R. Treatment of multiple myeloma with radioactive iodine and radioactive iodinated serum albumin. *Radiology*, Aug., 1955, *65*, 241–249. (From: Department of Medicine, Stanford University School of Medicine, San Francisco; City of Hope Medical Center, Duarte and Palo Alto Clinic, Palo Alto, Calif.)

The authors present the therapeutic results in 9 cases of multiple myeloma treated with I^{131}. Two forms of I^{131} therapy were employed: (a) massive doses of the isotope in patients pretreated with stable iodide, and (b) radioactive iodinated serum albumin (RISA). The diagnosis of multiple myeloma in all cases was established by examination of urine, peripheral blood and bone marrow, roentgenograms of the bones, and electrophoretic study of the plasma proteins.

Nine patients received a total of 24 doses of I^{131}, after preliminary stable iodine treatment to prevent loss of the circulating I^{131} to the thyroid gland. Total dose per patient ranged from 150 mc. given as a single dose, to 510 mc. given in five doses. Four of the nine patients gained strength and were relieved of pain.

Seven patients were given a total of 12 doses of RISA. Three of the seven obtained definite relief. Total dose of RISA, administered intravenously, ranged from 14 mc. given in one dose to 42 mc. given in four doses. It was found that 15 mc. RISA achieved approximately the same blood and marrow irradiation as 300 to 400 mc. I^{131}, and a body irradiation comparable to that resulting from about 200 mc. I^{131}. The ease of handling, decreased radiation exposure to personnel, elimination of urine collections, and ambulatory management of cases are all obvious

advantages of using RISA.

Relapse in 3 or 4 months was the rule. Retreatment was usually effective when relapse occurred. Management of a given cases, therefore, usually consisted of a series of treatments. Anemia was not improved, there was no lasting change in the serum protein pattern, and marked recalcification of bony lesions did not occur. Mild radiation sickness occurred in about one-third of all cases.

Consideration may be given to treatment with I^{131} or RISA (a) when whole-body irradiation is desired, (b) if the patient is not ambulatory or cannot be moved for roentgen therapy, (c) if local roentgen therapy is not advisable because painful areas are too numerous, and (d) if skin tolerance to roentgen rays has been exhausted.—*A. W. Sommer, M.D.*

Abbatt, John D., Brown W. M. Court, and Farran, H. E. A. Radiation sickness in man following the administration of therapeutic radioiodine; relationship between latent period, dose-rate and body size. *Brit. J. Radiol.*, July, 1955, *28*, 358–363. (From: External Scientific Staff, Medical Research Council, Department of Medicine, Postgraduate Medical School of London, Ducane Road, London, W. 12, England, and New End Hospital, Hampstead, London, England.)

The authors observed radiation sickness in 28 of 38 patients who were treated with I^{131}. The dosages varied from 290 to 300 mc. The patients were treated for varying conditions, but the general health of the patients who did not develop radiation sickness was no better than that of those who developed symptoms.

The energy absorbed in the body was calculated with the assumptions that all activity was uniformly distributed in the body with the exception of that known to be localized in the thyroid.

The symptomatic disturbances were noted to occur in two phases. The first occurred within 24 hours after administration of I^{131} and was characterized by fatigue, headache, nausea, and occasionally vomiting. The latent period prior to onset of symptoms was 4–13 hours. The duration of symptoms was 24–36 hours. The second phase was similar to the first but less severe. It occurred between 5 and 9 days following therapy. This phase of radiation sickness was noted in 11 of the 28 patients who had initial sickness. An associated finding in the second phase was a tenderness of the thyroid gland which persisted for 2 to 3 weeks. The authors designated this as "radiation thyroiditis."

Surface areas of each patient were calculated and from these data the dose-rate was expressed either as integral dose at 8 hours per square meter, or as mean integral dose per hour per square meter. It was found that highly significant relationships existed between dose-rate and latent period prior to onset of symptoms. The authors suggest that dose-rate may be an important factor involved in the production of symptoms of radiation sickness and feel that further investigation is warranted.—*D. V. Campbell, M.D.*

Hellriegel, W., and Pauly, H. Untersuchungen über morphologische Gewebeveränderungen durch Radiophosphor. (Investigations of the morphologic tissue changes produced by radioactive phosphorus.) *Strahlentherapie*, April, 1955, *96*, 557–568. (From: Universitäts-Röntgeninstitut, Frankfurt a.M., Germany.)

Radioactive phosphorus was given to mice, intravenously, in doses several times larger than the equivalent of any therapeutic dose in man. The phosphorus was evenly distributed throughout the body; no selective localization occurred in the first days after the injection. The testes showed atrophy, scarring and aspermia. The mitotically inactive liver, spleen and kidneys were also seriously damaged almost to the point of non-function. The authors suggest that such a result is explicable on the grounds that phosphorus plays an important role in the metabolism of carbohydrates, fats and proteins and thus generalized metabolic dysfunction is expected.

In mice given smaller doses of radioactive phosphorus and examined at the end of three months, none of these widespread changes was detectable; only the testes showed a decrease in spermatogenesis.

Since radioactive phosphorus will take part in general metabolic processes, generalized tissue damage must always be considered when it is used in man. It should be used therapeutically, especially in younger patients, only after critically weighing all the pros and cons.—*Henry G. Moehring, M.D.*

Rusche, Carl, and Jaffe, Henry L. Palliative treatment of prostatic cancer with radioactive colloidal chromic phosphate: Three years experience and results. *J. Urol.*, Sept., 1955, *74*, 393–401. (From: Departments of Surgery (Urology) and Radiology (Therapeutic), University of Southern California School of Medicine, and Department of Radiation Therapy, Cedars of Lebanon Hospital, Los Angeles, Calif.)

Eighty patients with inoperable prostatic carcinoma have been treated by the interstitial injection of radioactive colloidal chromic phosphate and observed during a three year period.

Through a classical suprapubic cystotomy, the prostate gland is thoroughly resected with a conizing

loop electrode. A revision of the bladder neck is carried out when indicated by the presence of obstruction. The bulk of the gland is removed by the electric loop and the isotope is injected into the remaining rim of periprostatic tissue and involved lymph nodes. Radioactive chromic phosphate is used because it has the relatively long half life of 14.3 days, it is economical and it avoids the usual protection problems that are customarily associated with gamma emitters. Chromic phosphate beta rays have a maximum range of 8 mm. in tissue and an average range of 2.5 mm.

Following the resection of the prostatic tissue the surgeon places multiple, long 21 gauge spinal needles, about 4 mm. apart, into the residual prostatic tissue. This is done with the index finger in the rectum, to avoid the complication of rectal fistula, which might occur if the radioactive substance were injected directly into the wall of the rectum. The solution of radioactive chromic phosphate is then injected. Each cubic centimeter of solution contains 2 mc. of chromic phosphate, 100 T. U. of hyaluronidase and a small amount of epinephrine. The usual dose is 0.3 to 0.5 mc. of chromic phosphate per gm. of prostatic tissue, and the average amount of isotope injected has been 25 mc. The maximum amount injected in any single case during this procedure was 40 mc.

The radiologist is in attendance at the operation to prepare the isotope and calculate the dosage, and he or the hospital physicist is responsible for the health physics and the monitoring of the operating room after the procedure has been completed. All instruments, linen and dressings are checked for radiation contamination, and properly cared for before the operating room is released for other purposes.

Three months after the initial suprapubic isotope injection the patient is re-examined. A transurethral resection is usually recommended for biopsy study and, if indicated, needles are again placed in the prostatic bed through the perineum with the operator's finger placed in the rectum for guiding the needle points. A cystoscope is in the bladder to prevent penetration of the needles in this direction.

The patient develops severe local radiation reaction in the prostatic area ten to fourteen days after the initial injection. This reaction reaches a peak in about four to six weeks, and gradually subsides over a period of ten to twelve weeks. During the peak of the reaction there is marked edema noted on rectal examination. The patient complains of rectal pain, frequency and dysuria.

One patient developed a rectal fistula, and this was due to the fact that the malignant tissue invaded the rectal wall. When the isotope caused regression of the tumor, a fistulous communication ensued. This type of case is therefore unsuitable for isotope injection, unless the patient is willing to accept a colostomy before or soon after the isotope therapy.

Fifty-nine patients have been followed from one to three years. Two of these patients have shown excellent results with no clinical evidence of residual disease and no evidence of cancer on biopsy examination. Thirty-seven patients have had marked clinical improvement and are living and well. Seven patients have had fair clinical results with moderate regression of disease. Thirteen patients have had poor clinical results; 10 of these are living. Nineteen patients have been treated too recently and insufficient time has elapsed to permit proper evaluation.

The authors are of the opinion that the interstitial use of radioactive chromic phosphate is a safe palliative procedure for carcinoma of the prostate when properly carried out.

Preliminary results of the interstitial irradiation of the advanced bladder carcinoma, by means of colloidal chromic phosphate in a small group of 7 patients have shown that 2 patients are living and free of disease eighteen to thirty months following treatment.—*George Chamberlin, M.D.*

NELSON, CHARLES M. Use of radioactive gold in the treatment of carcinoma of the bladder: report of 8 cases. *South, M. J.*, March, 1955, *48*, 245–250. (From: Medical College of Virginia, Richmond, Va.)

Because of 1) its relatively short half-life, 2) the preponderance (95 per cent) of beta activity, 3) the ease of producing it as a colloidal suspension and 4) its known cytotoxic effect on malignant cells, Au^{198} would seem to be well suited for use in the treatment of carcinoma of the bladder.

The author describes its use in 8 cases of bladder carcinoma in each of which Au^{198} was injected into the tumor tissue (1 millicurie/cc. of tissue) at 1 cm. intervals. Exposure was by means of a suprapubic cystotomy or in small lesions by cystoscopic control.

Although the treatment was given in all cases only as a palliative measure, the author was much encouraged by the initial results. He feels that Au^{198} is as effective as radium, radon, or roentgen therapy and is easier to administer than any of these.—*S. G. Belote, M.D.*

DOUGHERTY, JEAN H., BOWERS, JOHN Z., BAY, ROBERT C., and KEYANONDA, PANIT. Comparison of hematologic effects of internally deposited radium and plutonium in dogs. *Radiology*, Aug., 1955, *65*, 253–259. (From: Radiobiology Laboratory, University of Utah School of Medicine, Salt Lake City, Utah.)

Due to the increasingly widespread use of heavy radioactive elements, data concerning the permissible total body burden of these elements is becoming

of more and more importance. The authors, therefore, are making a study of the comparative effects of plutonium, radium, radiothorium, and mesothorium in adult beagle dogs. By using a species with relatively long life span and a sketelal growth pattern generally similar to that of man, they hope to contribute more reliable animal data for extrapolation to human beings.

The present report includes the hematologic alterations which are seen during the first year following injection of plutonium and radium. Dose levels of 2.5, 0.81, 0.27, 0.086, and 0.014 μc/kg. of each radioelement were used. These injected doses were based on a 90 per cent retention of plutonium and 25 per cent retention of radium. The lowest dose level (0.014 μc/kg.) was considered to be equivalent to the current human total permissible body burden of radium.

The only significant radiation effects detected during the first year were hematologic, except for the development, in one day, of acute radiation syndrome after receiving a retained dose of 2.5 μc/kg. of plutonium. No significant hematologic alterations were observed in animals receiving retained amounts of 0.086 or 0.014 μc/kg. of either plutonium or radium. With higher doses the degree of depression of leukocytes and platelets was found to be roughly proportioned to the amount of radioelement retained. There was no significant difference in the degree of leukocyte depression between plutonium and radium animals at comparable dose levels.

No alteration in blood platelets was seen in the 0.27 μc/kg. dogs. Those animals receiving .81 and 2.5 μc/kg. developed a thrombocytopenia which was maximal in 30 days and a return to normal was observed in 60 days. There was no significant difference in the degree of thrombocytopenia in the radium or plutonium dogs.

A depression of erythrocyte values was seen in 4 of the 5 dogs receiving 2.5 μc/kg. of plutonium. Only one of the 4 animals receiving 2.5 μc/kg. of radium showed a comparable depression of the hematocrit. The moderate anemia seen in the high level plutonium dogs was of brief duration and returned to normal within one month. Slight rise in sedimentation rate and slight reticulocytosis accompanied the anemia.

In general, the studies indicate that there is hematologic damage following injection of plutonium or radium at doses lower than heretofore reported for dogs or other species.—*A. Ralph Watson, M.D.*

Marucci, Horace D. The differential absorption of radioactive isotopes in artificially constructed and normal bladders in dogs. *Surg., Gynec. & Obst.*, Sept., 1955, *101*, 285–289. (From: Department of Urology, The Hahnemann Medical College and Hospital of Philadelphia, Philadelphia, Penna.)

The absorption of radioactive iodine, sodium, and phosphorus into the circulation from canine bladders after subtotal excision and reconstruction with seromuscular ileum grafts is small and comparable to the normal but, if the mucous membrane is preserved, absorption is markedly increased, by a factor of 4 to 20 times after two hours. In the case of sodium, 6½ per cent was measured in the circulating plasma after two hours. These results suggest that normal bladder epithelium and the morphologically indistinguishable seromuscular grafts are physiologically identical also.

A review of previous literature and details of the experimental technique are included.—*Raymond Quick, B.S.*

Kukita, Atsushi, and Fitzpatrick, Thomas B. Demonstration of tyrosinase in melanocytes of the human hair matrix by autoradiography. *Science*, June 24, 1955, *121*, 983–894. (From: Division of Dermatology, University of Oregon Medical School, Portland, Ore.)

Tyrosinase activity in pigmented melanocytes, as shown by the conversion of C^{14}-labeled tyrosine to melanin on the surface of the melanin granule, is demonstrated by an autoradiographic method.

The method is illustrated in its application to the matrix of the human hair bulb; tyrosinase is found in black but not in gray or albino hair and the absence in the latter case is said to be a genetically transmitted deficiency. While an active tyrosinase system is necessary in the hair matrix to supply the pigment for black hair, that of the epidermal melanocytes is normally inhibited but may become active in melanomata or following irradiation.

Technical details are included and the technique is applicable to the study of pigmented melanocytes in nevi and melanomas.—*Raymond Quick, B.S.*

CHEMOTHERAPY

Brown, W. M. Court. A clinical trial of cysteinamine (beta-mercaptoethylamine) in radiation sickness. *Brit. J. Radiol.*, June, 1955, *28*, 325–326. (Address: External Scientific Staff, Medical Research Council, Department of Medicine, Postgraduate Medical School of London, Ducane Road, London, W.12, England.)

The author has made a clinical assessment of the value of cysteinamine (beta-mercaptoethylamine) in altering the time of onset of symptoms of radiation sickness. He administered doses of 160 to 300 mg. of the drug intravenously within three minutes before commencement of irradiation and within one hour of termination of irradiation. The subjects

were patients with postoperative ovarian malignancy in which no metastases were present.

Using an adequate control series, the conclusion was reached that cysteinamine does not significantly affect the time at which symptoms of radiation sickness develope.—*Arch H. Hall, M.D.*

MISCELLANEOUS

Doub, Howard P. (Detroit, Mich.) Dr. Augustus W. Crane: 1868–1937. *Radiology*, July, 1955, *65*, 3–7.

The author pays tribute to Dr. Augustus W. Crane (1868–1937), one of the true pioneers in the field of radiology.

Dr. Crane's contributions to his chosen specialty were many and diverse. Nearly fifty published articles by this "clinician radiologist" covered a wide variety of subjects. He was a true pioneer in the field of gastrointestinal roentgenology. He was perhaps most interested in his studies of the heart and lungs, and his outstanding work on diseases of the chest made him known internationally. He was the recipient of many honors and awards for his inventions and his contributions to medical knowledge.

During his early professional life he carried on private practice in internal medicine, and only later restricted his work to consultation, in which roentgenology claimed his dominant interest. His early devotion to clinical medicine remained with him throughout his life. He is credited with the timely warning that if the radiologist did not remain a clinician, the clinician would become the radiologist. —*A. W. Sommer, M.D.*

Gustafson, P. F., and Marinelli, L. D. A spectrometric method for the study of radon partition in radium-burdened animals. *Radiology*, July, 1955, *65*, 90–95. (From: Division of Biological and Medical Research and Radiological Physics Division, Argonne National Laboratory, Lemont, Ill.)

The fraction of radon retained in a radium-burdened animal can be determined experimentally in vivo by measuring with scintillation spectrometers the relative intensities of Ra^{226} and RaB gamma rays emitted by the animal and by comparing them to those obtained with properly deemanated Ra sources placed in suitable phantoms. This method overcomes the inaccuracies and uncertainties of other procedures in which the radium burden is obtained by measuring both the gamma-ray activity of the Ra(B+C) retained in the body and the time rate at which radon is lost in the breath.

The soundness of the technic has been proved by experiment on rabbits and dogs. Although the method has not been used to study human beings, the results obtained suggest no contraindications to this possibility. It can also be used to study in vivo the metabolic equilibrium of other radioactive series. —*A. W. Sommer, M.D.*

Cogan, David G., Fink, Robert, and Donaldson, David D. X-ray irradiation of orbital glands of the rabbit. *Radiology*, May 1955, *64*, 731–737. (From: Howe Laboratory of Ophthalmology, Harvard Medical School, Massachusetts Eye and Ear Infirmary, Boston, Mass.)

The effects of irradiation on the two orbital glands of the rabbit were studied as a part of a comprehensive investigation of the effects of irradiation on the eye. In man the harderian gland, a sebaceous gland, is vestigial, but the lacrimal gland of the rabbit is similar to that in man, and it possibly plays some role in the keratoconjunctivitis following irradiation. Also, it is important, since it is sometimes irradiated for epiphora.

The right eyes of 100 rabbits were irradiated with doses of 75 to 4,000 r, from a 1.2 mev. roentgen ray apparatus. At various intervals the animals were sacrificed, and the orbital glands of both sides studied and compared.

It was found that both types of glands underwent a significant reduction in size when irradiated with 1,000 to 4,000 r, but there was little histological change. The harderian glands showed some pleomorphism of glandular cells and nuclei, coarsening of the cytoplasmic inclusions, and a mild increase in stroma. The lacrimal glands showed little direct parenchymal effect, but in some there was an infiltration by inflammatory cells, probably associated with the radiation-induced keratoconjunctivitis.—*C. L. Stevenson, M.D.*

Dillon, John B. Fires and explosions in anesthesia. *Radiology*, July, 1955, *65*, 108–110. (From: Department of Surgery [Division of Anesthesia] of the University of California Medical Center, Los Angeles, Calif.)

The chance that an explosion or fire will occur while a patient is under an anesthetic is very slight, if the proper safeguards of hospital construction and anesthetic administration are employed.

An explosion or fire may occur when three conditions are present:

1. Sufficient concentration of explosive gas or vapor;
2. Oxygen or other combustion-supporting gas;
3. Source for ignition.

Most anesthetic agents are explosive, and although chloroform and trichlorethylene vapor will not explode, their products of combustion are noxious gases. They must not be used in areas where ignition might occur. Since all anesthetic agents are given with 20 per cent oxygen, the second condition

is met. The presence of nitrous oxide enhances the chance of explosion, even though it itself will not explode.

The common sources of ignition are: (1) static electricity; (2) nonstatic sparks emanating from equipment; (3) open flames. The static electricity factor can be controlled by the establishment of a common electrical pathway and the elimination of sources of static production. By employing explosion-proof or high wall outlets, using underwriter approved equipment, and completing all crcuits before anesthetic induction, nonstatic sparking can be avoided. Proper ventilation will prevent concentration of the gases and vapors in the area. No open flames should be permitted in areas where anesthetic agents are being used.

The presence of methane in intestinal gas may be factor for the radiologist to consider in large bowel investigations. Explosive concentration of hydrogen can be released in the bladder during procedures in which hydrolysis of water occurs. *C. L. Stevenson, M.D.*

Klein, I. An improved x-ray stand. *Radiology*, Sept., 1955, *65*, 420–421. (Address: 100 Central Park South, New York, N. Y.)

A light sturdy portable roentgen stand which is made primarily of aluminum tubing is described. It is easily assembled and dismounted and can be adapted readily to both upright and prone positions.—*Harold C. Hamilton, M. D.*

Steinberg, Israel, Dubilier, William, and Evans, John A. New twelve by twelve-inch roll film magazine for rapid serial roentgenography. *Radiology*, Aug., 1955, *65*, 276–280. (From: Department of Radiology, The New York Hospital-Cornell Medical Center, New York, N. Y.)

With the development of a new commercially available trouble-free 12 by 12 inch roll film magazine, serial roentgenography of enlarged hearts, most of the pulmonary circulation, the abdominal aorta, and the splenoportal system becomes more practical. Smaller film sizes can also be employed, when desired. An electronic timer employing high milliamperage and kilovoltage allows exposures as fast as 1/60 second with high kilovoltage at 48 inch target film distance. The exposure rate is two films per second, and 70 films can be obtained from each 75 foot roll of 12-inch size.

The only disadvantage is the limited exposure rate of two films per second, and efforts are being made to increase the speed.—*C. L. Stevenson, M.D.*

Shapiro, Robert. An experimental study of zirconium compounds in contrast radiography. *Radiology*, Sept., 1955, *65*, 429–432. (From: Department of Radiology, The Hospital of St. Raphael and The Yale University School of Medicine, New Haven, Conn.)

A review of the chemistry and biology of zirconium suggests that this element might be an ideal contrast medium, since it is relatively nontoxic and has none of the disadvantages of the ordinary halogen derivatives. A number of investigators have reported no toxic effects when a finely divided suspension was injected intravenously, intraperitoneally or intratracheally in animals. Various soluble salts of zirconium also give evidence of low toxicity.

The author was able to corroborate the low toxicity of zirconium administered orally and intraperitoneally in the form of a 25 per cent aqueous solution of zirconium glycolate and lactate, and a 25 per cent suspension of zirconium oxide. Intravenous injection of the zirconium oxide suspension in guinea pigs and rabbits consistently produced pulmonary infarction and death. This was probably due to the inability to produce a stable colloidal suspension.

Roentgenograms, in air and water phantoms, of finger cots containing zirconium compounds showed these to be unsatisfactory for contrast roentgenography in man.—*A. W. Sommer, M.D.*

Leinfelder, P. J., Evans, T. C., and Riley, E. Production of cataracts in animals by x-rays and fast neutrons. *Radiology*, Sept., 1955, *65*, 433–438. (From: Departments of Ophthalmology and Radiology and Radiation Research Laboratory. College of Medicine, State University of Iowa, Iowa City, Iowa.)

The authors have presented their observations derived from a study of cataracts produced by roentgen rays and fast neutrons, using mice and rabbits as the experimental animals. As has been observed in man, the effects produced in animals may be minimal with very little disturbance of vision, or marked with resulting total blindness. The intensity of the opacification in the lens is related to the dose, fractionation and quality of radiation.

From their own experiments and a study of the work done by others, it is postulated that ionizing radiation injures (primarily) the growing cells of the lens epithelium. Although a few cells are killed, the main observable effect seems to be upon mitosis. The rate of mitosis is retarded, but in addition some change appears to take place that prevents the production by the cell of a normal lens fiber. As growth of the lens continues, distorted and aberrant fibers are formed that disturb the otherwise homogeneous pattern of the lens and form an opacity.

When the cataractous effect of neutrons was first demonstrated, the similarity to the effect of roentgen rays was noted. Early investigations suggested a ratio of perhaps ten to one, as measured by the ionization chamber (neutrons being most cataracto-

genic). More recently it has been found that particular organs may be especially sensitive to the dense ionization produced by fast neutrons. The lens of the eye is especially susceptible to this form of radiation. Although the absolute values were different, the relative effects were found by the authors to be the same as those shown by others in earlier experiments. The earlier finding of greater recovery (as regards cataractogenic action) from roentgen ray exposure was confirmed, and it was shown that the lens recovers little from fractionated neutron treatment. Also, results seem to indicate that the higher the energy of the neutrons, the less the biologic effect, both for LD50 and for cataract production. Preliminary evidence seems to indicate that an optimum linear transfer may be demonstrated for the production of lens opacities.—*A. Ralph Watson, M.D.*

FRITZ-NIGGLI, H. Vergleichende Analyse der Strahlenschädigung von Drosophila-Eiern mit 180 KeV und 31 MeV. (Comparative analysis of radiation damage of Drosophila eggs with 180 kv. and 31 mev.) *Fortschr. a d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, Aug., 1955, *83*, 178–200. (From: Strahlenbiologisches Laboratorium der Radiotherapeutischen Klinik des Kantonsspitals, Zürich, Switzerland.)

Eggs of *D. melanogaster*, enclosed in a plexiglass phantom, were irradiated at different stages of their embryonal development (1, 1½, 3, 4, 5¾, and 7 hours). Comparable samples were subjected to conventional roentgen rays (180 kv., 6 ma., 1.0 mm. Cu, 255 mm. and 293 mm. target skin distance, 59 r/min., tube opening limited by a lead ring with 16 cm. diameter, eggs placed at a depth of 13 mm. plexiglass) and to megavoltage roentgen rays (31 mev. betatron, no equalizing filter, 70 r/min. centrally at 540 mm. target skin distance, and 61 r/min. in the center at 791 mm. target skin distance, circular field of 4 cm. diameter, eggs placed at a depth of 41 mm. plexiglass).

The eggs appeared most sensitive to radiation at the age of 1¾ hours (±¼ hr). Based on extensive mathematical analysis (detailed at great length in the paper), the author asserts that both types of radiation cause the same quantitative and qualitative effect on eggs younger than 3 hours, i.e., prior to gastrulation. Conversely, in older eggs (4, 5½, and 7 hours), megavoltage radiation appeared definitely less effective. A tentative interpretation is offered: the early death, most often seen before the age of 3 hours, would be due to action upon certain chromosomes, which in turn prevents gastrulation; late death (with yellow discoloration from transdermic extravasation of blood and lymph), frequent in older eggs, is possibly caused by the destruction of some chemical substances necessary for survival.

Mention is made of the fact that in the present state of our knowledge, measurement of radiation emitted by megavoltage sources is not as dependable as one might desire for experimental purposes of comparison.—*E. R. N. Grigg, M.D.*

SEAMAN, WILLIAM B., TER-POGOSSIAN, MICHEL M., and ITTNER, WILLIAM B., III. The relative biologic effects of x-rays and beta rays. *Radiology*, Aug., 1955, *65*, 260–264. (From: The Edward Mallinckrodt Institute of Radiology, Washington University School of Medicine, Saint Louis, Mo.)

The authors present a preliminary report of their studies of relative biologic effects of medium voltage (120 and 200 kv.) roentgen rays and beta rays emitted by P^{32}. The ear of the white rabbit was chosen as the test object. A circular area 2 cm. in diameter in the midportion of the ear was irradiated with 200 kv. roentgen rays, 120 kv. roentgen rays or beta rays. In each instance the other ear of the same rabbit was used as a control. The production of a moderately intense dry erythema was chosen as the easiest recognizable end point. The irradiation rate and over-all time of irradiation were roughly comparable. Homogeneous distribution of the beta rays was accomplished by placing the rabbit ear between two opposing P^{32} plaques.

The first series of rabbits was irradiated with 120 kv. roentgen rays and P^{32} in doses varying from 750 to 7,500 r. In the second series all animals were given 2,000 r to a 2 cm. diameter circular area on the left ear with 120 kv. roentgen rays with 1 mm. Al filtration at 20 cm. distance. An area of similar size and position on the right ear was given 2,000 rep from a double P^{32} plaque. A third series of 13 rabbits was irradiated with 200 kv. roentgen rays with 1 mm. Al filtration and 20 cm. focus-skin distance. Seven animals were given 3,000 r with roentgen rays to the left ear and 3,000 rep with P^{32} to the right ear. The remaining 6 were given 6,000 rep with P^{32} to the right ear and 3,000 r with roentgen rays to the left ear.

The conclusion is that, with equal doses and similar physical distribution in tissue, the beta rays of P^{32} are slightly less than one-half as efficient as 200 kv. roentgen rays in producing erythema on the rabbit's ear.—*A. W. Sommer, M.D.*

BLOUNT, HENRY C. JR. Effect of magnesium on the response of mice to large doses of whole-body irradiation. *Radiology*, Aug., 1955, *65*, 250–252. (From: U. S. Public Health Service Hospital, Seattle, Wash.)

The effect of magnesium upon the response of mice to large amounts of whole-body irradiation was studied. It has been previously shown that the

injection of magnesium into an animal causes a decrease in body temperature, and this, with decreased metabolic rate, can increase the animal's resistance to irradiation.

Groups of mice were given intraperitoneal injections of 5 to 15 mg. of aqueous solutions of magnesium sulfate, five minutes before receiving whole body irradiation. Each received 625 r (measured in air, including backscatter). The technical factors were: 250 kv.; 30 ma.; 0.25 mm. Cu plus 1.0 mm. Al added filtration; target skin distance 70; 71 r per minute, plus or minus 1 r; and 1.1 mm. Cu half-value layer. Controls were given 1 cc. of normal saline solution intraperitoneally, prior to irradiation. Thirty per cent of the group that received 15 mg. of magnesium sulfate died of the medication, but none of those receiving less amounts died from this.

It was found that the injection of 15 mg. of magnesium sulfate significantly protected mice receiving whole-body irradiation, but lesser amounts had no significant effect. This correlated well with the amount of decrease in body temperature that was observed.—*C. L. Stevenson, M.D.*

Genna, S., and Laughlin, J. S. Absolute calibration of a cobalt-60 gamma-ray beam. *Radiology*, Sept., 1955, *65*, 394–407. (From: Division of Physics and Biophysics, Sloan-Kettering Institute, New York, N. Y.)

The authors have described a method of calorimetric determination of the amount of energy in the collimated gamma-ray beam from a cobalt 60 source, and the amount of ionization produced by this beam under specified conditions. These measurements experimentally relate absorbed dose and quantity of radiation. Comparison of this experimentally determined relationship is made with the calculated relationship predicted by theory, permitting critical evaluation of the theory under the specified conditions.

Measurements with two secondary standards were made for correlation with the calorimetric results. The first standard is the roentgen as measured with a 25-r Victoreen thimble chamber, and the second is a polystyrene wall extrapolation chamber measurement of cavity ionization.

A detailed description of the apparatus used is included.

The authors have summarized the results obtained in their experiments and measurements here presented as follows:

1. A calorimetric method of determining the quantity of radiation (ergs/cm.^{2}) in a beam of radiation with precision is described.

2. The application of this method to the gamma ray beam from a cobalt 60 source is reported with the result of 3,370±130 ergs/cm.^{2} per roentgen where the roentgen measurement is based on the calibration of a secondary standard at the National Bureau of Standards.

3. It is shown that theoretically, under these conditions, the roentgen is expected to correspond to a quantity of radiation of 3,250 ergs/cm.^{2} per roentgen.

4. The design and operation of a precision extrapolation chamber are presented.

5. The extrapolation chamber was employed to determine that in an air cavity imbedded at a depth of 0.726 gm./cm.^{2} in polystyrene, the ionization density is 0.96 esu/cm.^{3} per roentgen in air.

6. The utilization of the total degraded electron spectrum in the interpretation of absorbed dose from cavity ionization measurements is illustrated. For an air cavity in polystyrene, the result is 98.8 ergs/gm. per esu/cm.^{3}.

7. The method of combining the calorimetric determination of quantity of radiation with a depth dose curve to obtain the absorbed dose is illustrated. The result for polystyrene expressed per unit cavity ionization density is 100.1 ergs/gm. per esu/cm.^{3}.

From the studies here presented it is determined that it is technically feasible to determine precisely the quantity of radiation in the gamma-ray beam from a cobalt 60 source. It is further demonstrated that the quantity of radiation combined with a depth-dose curve yields the absorbed dose at any desired depth in an absorber. The absorbed dose so determined in a polystyrene absorber on the basis of a calorimetric measurement agrees closely with the absorbed dose calculated on the basis of cavity ionization. The use of the total degraded electron spectrum was illustrated in this latter calculation.

The utility of this calorimetric method as a primary standard suitable for the calibration of secondary standards is established. Its utility in the determination of absorbed dose is also exhibited. The validity of the Bragg-Gray cavity ionization relation employed with the total degraded electron spectrum is justified by comparison with the calorimetrically determined absorbed dose.—*A. Ralph Watson, M.D.*

Markus, B. Über Dosisverteilungen schneller Elektronen von 3 bis 15 MeV und einige physikalische Bestrahlungsbedingungen beim medizinischen Siemens-Betatron. (Concerning the dose distribution of 3–15 mev. fast electrons, and several physical conditions affecting radiation from the Siemens medical betatron.) *Strahlentherapie*, July, 1955, *97*, 376–381. (From: Universitäts-Hautklinik, Abteilung Elektronenschleuder, Göttingen, Germany.)

The author publishes curves for the distribution of the specific dose, measured by a film method, of 3–15 mev. fast electrons in a solid water-equivalent phantom. He discusses the influence particularly of geometric factors on radiation qualities, and the decreased abruptness of the rise and fall of curve of depth doses with increased energy of the beam.—*Henry G. Moehring, M.D.*

OLIPHANT, W. D. Xeroradiography. I. Apparatus ard method of use. *Brit. J. Radiol.*, Oct., 1955, *28*, 543–544. (Address: Ferranti, Ltd., Edinburgh, Scotland.)

In 1937 Chester F. Carlson described and patented a new photographic process, which depended for image reproduction on electrostatics and triboelectricity. In view of the essentially dry nature of the process, in contrast to silver halide photography which requires wet chemical processing for image development and fixation, it was named xerography.

Xerography depends fundamentally on the properties of thin films of certain photoconductive insulating materials such as anthracene, sulfur and amorphous selenium. Of these amorphous selenium is best.

A xerographic plate consists essentially of a mechanically rigid backing plate, which must possess a certain amount of electrical conductivity, on one surface of which is deposited uniformly a film of amorphous selenium 50 to 100 μ thick. Prior to sensitization the plates are unaffected by radiation but the selenium surface must be protected from mechanical damage. The plate is rendered sensitive by charging it in the dark to a positive potential of 400 to 500 v., using the corona discharge from a suitably shaped electrode.

A sensitized plate must be kept in a cassette fitted with a roentgen-ray transparent dark slide, but is handled in the same manner as a roentgenographic film during exposure. The charge on the surface of the plate is modified by the radiation incident on it. The charge distribution remaining on the plate constitutes an invisible electrostatic image. This image may be revealed by the powder cloud method, which deposits a powder in proportion to the charge density, surface potential or field strength. Such development can give rise to either a positive or negative picture depending on the charge sign on the powder particles. The potential distribution across the surface of the plate is an important factor in the fidelity of reproduction.

The degree of resolution obtained in the final picture is dependent solely on the size of the powder particles employed. In present practice a white cosmetic face powder is quite suitable.

Once the image has been developed it may be examined, photographed, projected on to a screen, or the powder may be transferred to a suitable adhesive paper. The remaining powder may then be wiped carefully off the surface of the plate and the plate may be used again.—*Arthur B. Smith, M.D.*

HILLS, T. H., STANFORD, R. W., and MOORE, R. D. Xeroradiography. II. The present medical applications. *Brit. J. Radiol.*, Oct., 1955, *28*, 545–551. (Address: T. H. Hills, Guy's Hospital, London, S.E.1, England.)

Comparison of xeroradiographs of thin parts of the body with conventional roentgenograms reveals that bone detail is better shown on the roentgenogram, while soft tissue frequently shows clearly and with greater contrast on the xeroradiograph. Three variables affect the detail of a xeroradiography, these are the time for which the plate is charged, the roentgen-ray exposure and the time for which the exposed plate is subjected to the powder cloud. A xeroradiograph may fail to show detail because of distortion and this has been described as the "pull-in" effect. Development time is not critical and may be varied as much as 25 per cent either way with no ill effect. As far as thin sections of the body are concerned the latitude in charge time is small if distortion is to be avoided.

The evidence suggests that xeroradiographic plates are 2½ times slower than standard non-screen film and up to 10 times slower than screen film. Because of the increased exposure necessary the use of xeroradiographs in thick regions of the body has been limited.

Present application of xeroradiography in medicine is limited primarily by the increased exposure required. Both bone detail and soft tissue are well demonstrated if care is taken to avoid distortion. There is some evidence that a fracture line difficult to detect on a conventional roentgenogram may be seen more easily on a xeroradiograph. The powder is the only expendable item and the entire process of charging and developing the plate occupies less than a minute, with the finished picture available for inspection about half a minute after exposure.—*Arthur B. Smith, M.D.*

JOHN E. WIRTH